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## SCIENCE OF THE HORSE'S MOTION.

In our SUPPLEMENT, No. 158, January 1?, 1879, we gave an extended series of engravings, then for the first time printed, of the remarkable pictures of the horse in motion, as revealed by Mr. Muybridge's instantaneous photographs, taken in California, at the instance of Gov. Stanford. These pictures show that the impressions produced upon the human mind through the eyes, in closely watching the motions of a horse when running a certain distance, are very different from the impressions which will be made during the same run upon a highly sensitive photographic plate.

In a recent number of the *American Queen*, we find a peculiar drawing, which is of value as illustrating at one view these extraordinary differences of impressions.

The two upper figures show the impressions ordinarily made upon the mind's eye by the horse and rider in the acts of running and leaping. Here we have grace, vigor, and strength very well exemplified. The smaller figures below are mostly made from the instantaneous photographic pictures before mentioned, with this important qualification, however, that while many of the positions of the horses are correctly taken from the photographs, the positions of the riders are, we suppose, the work of the fancy of the artist. There is an old adage that things are not what they seem to be; and it is proverbial that the eye of man is an organ that is easily deceived. It is certainly, at present, an agreeable kind of illusion which makes us see the horse as we do see it, and not as the photo plate sees and records it.

It is possible, however, that in the future, now that the photograph points out so many forms and motions that have escaped our attention, we may be able to sharpen our eyes, and hereafter to see things about the horse to which heretofore we have been blind. And it may come to pass that all those singular attitudes shown in the lower part of our illustration, which now seem so absurd and awkward, will become endowed with grace and beauty in our minds, while the old forms will be dismissed as untruthful and therefore ugly.

THE POPULAR NOTION OF A HORSE TAKING A LEAP.
IN THE SCENE BELOW CAN BE NOTICED THE DIVERS POSITIONS TAKEN BY HORSES AT AND OFF A JUMP.
THE ACCEPTED IDEA UP TO THE PRESENT DAY OF A HORSE AT FULL SPEED.
IN THE MANY GALLOPING POSITIONS BELOW IT WILL BE SEEN THAT NOT IN ONE SINGLE INSTANCE DOES A HORSE APPEAR WITH ALL FOUR LEGS EXTENDED AT ONCE AT GALLOP.
THE PICTURE REPRESENTS A HUNTING EPISODE: "FULL CRY." EVERYTHING IS ON A RUSH. HORSES GOING AT UTMOST SPEED. IT IS A CAREFUL NATURAL REPRESENTATION. THE MOTIONS ARE GIVEN AS THEY ARE IN NATURE. ALL POSITIONS ARE COPIED FROM Mr. MUYBRIDGE'S PHOTOS. ALL OF THE GALLOPING MOVEMENTS COVER BUT ONE STRIDE OF ONE HORSE THAT IS: EACH SEPARATE POSITION IS A PORTION OF A SINGLE STRIDE
THE SAME REMARK APPLIES TO THE JUMPING BEING AT A CONSIDERABLE DISTANCE OFF.

SCIENCE AS APPLIED TO THE MOTIONS OF THE HORSE.—THE REAL AND THE IDEAL.

## REDUCTION OF PHOTOGRAPHIC WASTES.

By W. L. SHOEMAKER.

THE following recipes are the result of the experiences of many. Some of the notes are very important. If followed closely you may, as I have many times done, reduce photographic wastes to $\frac{999}{1000}$ fine.

### PAPER CLIPPINGS.

Burn the papers to a fine ash; then mix with one and a half its weight of the following flux:

| | |
|---|---|
| Bicarbonate of soda | 1 pound. |
| Pearlash | 1 " |
| Common salt | 4 ounces. |

Pack very tight; have all the fluxes well pulverized before mixing. After the mixture becomes liquid in the pot add additional quantities in small lots; if it effervesces add common salt; it settles it promptly. Just before removing the pot from the fire add a little pinch of willow-charcoal. This will clear the flux of any little globules that may hang in it.

FOR CHLORIDE OF SILVER.

Filter; wash on filter well, dry, and mix with one and a quarter its weight of flux—

| | |
|---|---|
| Bicarbonate of soda | 1 pound. |
| Cream of tartar | 4 ounces. |

Pack tight; do not add any to the pot.

SULPHURET OF SILVER.

Dry; pulverize in a mortar; then roast on shovel at a low heat until flame ceases; stir occasionally; mix with one and three-quarters its weight of flux—

| | |
|---|---|
| Bicarbonate of soda | ½ pound |
| Pearlash | 1 " |
| Nitrate of potash (refined) | ½ " |

See that the flux contains no lumps; have it well pulverized; pack the crucible not quite full, and merely shake it down. Additional quantities may be added to the pot before it becomes liquid. Add salt if it effervesces.

FOR DEVELOPER (DARK ROOM WASTES).

Dry; roast on shovel until the sulphur is thoroughly burned off; place the reddish brown powder in an evaporating-dish; pour on common muriatic acid; apply a gentle heat for at least ten minutes. This dissolves the iron, and leaves the silver as a gray powder. Dry; mix with one and three-quarters its weight of flux—

| | |
|---|---|
| Bicarbonate of soda | 1 pound. |
| Pearlash | 1 " |
| Common salt | 1 " |

GOLD FROM TONING-BATHS WHICH HAVE BEEN PRECIPITATED WITH IRON.

Dry, and roast on a shovel for a few minutes at a dull heat; then put the reddish brown powder in a cup, and pour on *pure* muriatic acid, and apply a gentle heat for five minutes. This dissolves the iron, leaving gold and silver as a precipitate. Pour off the iron solution; wash well; dry, and melt by mixing with five or six times its weight of pearlash. The fire should be fresh and clean before each pot is inserted.

Pack the pots, and set in a bucket of water near to the top of the pot—be careful not to wet the flux; leave in water a few minutes, then place in fire.

Have another pot inverted (with the bottom knocked out) as a lid to cover the pot while in the fire. After melting leave pot cool and crack open for the button. When all the buttons are collected place them in a pot; after melting add a little at a time of willow-charcoal until the surface is clean.

Then pour into a bucket of clean water; slightly agitate the water while so doing. This will give you the metal in a fine, granulated condition that tests easily; or for making nitrate of silver.—*Philadelphia Photographer.*

## ON THE CONDITION AND CHARACTERISTICS OF SOME OF THE NATIVE TRIBES OF THE HUDSON'S BAY COMPANY'S TERRITORIES.*

By JOHN RAE, M.D., LL.D., F.R.S., ETC.

IN limiting my remarks to only a few of the native tribes of what are called the Hudson's Bay Company's Territories, I am actuated by two principal motives:

1st. Because I desire to speak only of those tribes of whom I have, more or less, some personal knowledge.

2d. Were I to attempt to give even the most brief history of all the tribes that are to be found in this vast extent of country, not one, but at least half a dozen papers would be required for the purpose; and to look up authorities and give information derived from them would not be an expression of my own views, but of theirs. It may be that, in the course of this paper, I shall have once or twice to step over the boundary-line of the territory I have prescribed, but this, if done at all, will be very briefly, and only for the sake of illustration.

The whole of the aborgines of British North America have, for convenience of classification, been divided into four races, which, beginning at the North, are as follows:

1st. The Eskimos, Esquimaux (Innuit or Innok), stated to amount to about 4,000 persons, and living on the Arctic seaboard, from Behring Straits, with slight intermission to Labrador, a distance of about 5,000 miles.

2d. The Denè-Dindjié, which embraces eleven tribes, east of the Rocky Mountains, from the Athabasca District to the Eskimo lands on the confines of the Arctic Sea, numbering about 22,000 individuals, and occupying about one million square miles of country.

3d. The Algonquins, comprehending twelve tribes, over a very large tract of country of irregular form, from near the shores of Labrador to the Rocky Mountains.

4th. The Hurons-Iroquois, found chiefly on the shores of Lake Huron and the Ottawa River, and in the province of Quebec.†

I further beg to remind those whom I have the honor of addressing, that my information is by no means of recent date, being from twenty-eight to forty-five years antecedent to the present time, so that the conditions of some of those tribes about whom I speak may have undergone a material change, either through the influence of the many zealous missionaries who have visited and been stationed among them since that time or from other causes.

During a ten years' residence at Moose Factory, as surgeon, I had many and fair opportunities of studying the habits and character of the Crees of the woods, called also Maskeg, or Swampy Crees. This tribe is estimated to number about 3,000, and is found all along Hudson's Bay, from East Main to Churchill, in the north-west, then westward to Norway-house, Lake Winnipeg. The same Indians are also said to inhabit the lands lying between Hudson's Bay and the Gulf of St. Lawrence. Of this fact I have no personal knowledge, but my authority is, I believe, to be perfectly relied upon, as he has seen them, and says that they very much resemble the Crees at Moose, and speak very nearly the same language.

At Moose, the word "No" is *numma-wila;* at Rupert's-house, *nummawia;* at Albany, *nummuwina;* and at St. Lawrence Gulf, *numma.* At Moose, I have heard all or any of these words used for "No."

The Wood Crees, or "Swampies," are about the average height of Englishmen, or, perhaps a little taller, but there is as much variety in this respect as among ourselves. They have a good capacity of chest, but are rather round than broad, are strong and active, being good walkers, and able to haul heavy sledges and carry heavy loads over the portages, being very capable voyagers, both in boats and canoes. They are so trustworthy that they are often sent long voyages with valuable cargoes of goods or furs, having no white man with them, and deliver their charge at its destination safely, and usually in better condition than the cargoes sent under the management of the company's regular servants.

The women cannot be said to be pretty, but they have a very pleasing manner and expression of face, and their soft agreeable voices make them, especially when young, by no means unattractive.

The clothing of both sexes, in times prior to the advent of the Hudson's Bay traders, must have been chiefly composed of reindeer skins and furs of various kinds, of which, no doubt, rabbit skins (*Lepus americanus*) formed an important part. At the time of which I speak, the winter dress of a man consisted of a stout blanket coat, with a dark blue hood, one or two woven flannel shirts, leggings of strong blue, red, or white cloth, coming high up on the thigh, an assyan or breech cloth, large leather mitts, with blanket lining, and moccasins, having a fold or two of *duffle* inside. A cap of coarse fur is also sometimes worn. The coat is confined at the waist by a scarlet or striped worsted belt, long enough to pass with ease twice round the body. To this belt on one side is suspended that most necessary and useful article, a fire bag, containing pipe and tobacco, flint and steel, box of brimstone, matches, touchwood and tinder, and one or two other odds and ends. To balance this, on the other side, are the small trapping ax, useful, if not absolutely requisite, for many purposes, and a sheath knife. If on a hunting excursion, a powder horn is hung over one shoulder, and a pouch, with shot and ball, over the other, which, with a long single barrel flint gun of very small caliber, completes his equipment. If the man is to be absent a night or two, a blanket (all his bedding, however cold it may be), with a few pounds of dried meat or fish, and a tin pot, in which to thaw water for drinking, is added to the above very simple outfit. It may be asked, What about cooking? That is a very easy matter. The meat, fish, or whatever else it may be, is placed firmly on a pointed piece of stick, and stuck up before the fire, and thus speedily cooked, making what is called a "ponask," and a very pleasant supper it constitutes after a long day's march on snowshoes, about the finest exercise a man can take. The Indian, when traveling or hunting, eats very little breakfast, but a mighty big supper.

The summer dress is very similar to that worn in winter, only the capot or coat is of thinner material, and of a gray or blue color, a striped cotton shirt takes the place of a woolen one, and the big mittens are laid aside.

The women's dress is usually of blue cloth, long enough to come within six or eight inches of the ground, leggings ornamented with ribbon or colored gartering, moccasins, and a cap made of a piece of cloth about 18 inches long, and the same in width, doubled and sewn up at one end. It is ornamented like the leggings, but a considerable amount of bead work is often added. This form of cap is very useful in preventing the snow from falling on the nape of the neck when walking among the snow covered woods in winter; colored cotton handkerchiefs and small shawls are also much worn. The hair is usually tied into a cue behind, in the most simple form.

The Cree women are not generally harshly treated by their husbands, but they have some very hard work to do in carrying heavy loads, and hauling sledges with the greater part of the baggage of the family, when changing camp. Their tents are made of reindeer skin, when the man is a good hunter, or rich enough to buy the necessary skins; when too poor to do so, they prepare long strips of birch bark, about 18 inches wide, peeling it as thin as possible. These roll up very snugly, are by no means heavy, and form good shelter when properly placed round the tent poles.

The routine of a year's life of a Wood Cree is very much as follows: He, and probably his wife, come into the Fort, generally about the middle of April, with the furs obtained in the winter. These he either barters for goods, or, what is more likely, pays for an outfit he has received in the autumn on credit; and, if there is anything left over, purchases what he is most in need of.

I should here mention that all Indian hunting grounds are almost as well defined as the estate of an English gentleman; and if an Indian were to destroy a beaver house, and kill the beaver in it, on a neighbor's domain, he would be considered guilty of a very disreputable piece of poaching.

It has been the desire of the Hudson's Bay Company to carry on a ready-money barter with the natives, but the improvidence of the Indians has always frustrated the attempt. Debts have been canceled over and over again with this object, to no purpose. If paid for their goods in the spring, the Indians squandered all they received before the end of the summer, and had to be supplied with a fresh stock of articles for their winter use. If his object is to shoot wild fowl, the man is supplied on credit with ammunition, and, about the end of April, proceeds to some favorite feeding place of geese and ducks on the coast, and there pitches his tent. Here, if a moderately good shot, he lives in comfort and abundance for four or five weeks, besides, perhaps, sending some hundreds of geese, with their feathers and quills, to the Fort, to be traded for ammunition.*

The manner of goose and duck shooting in these parts is very simple, yet requires considerable judgment. The Indian collects a large bundle of willows and grass, and approaches the wild fowl feeding grounds. He then sits down, and for a time watches the direction of flight of the birds, which, in windy weather, and at certain times of tide, are very restless. Having selected a spot, usually near a pool of water, he makes an inclosure of the willows, large enough to sit comfortably inside of. The grass is used to sit upon, and also to mix with the willows that form the shelter, to make them as little conspicuous as possible; this is called a "stand." At the edge of the pool of water he sets up a number of pieces of hard mud, about the size and something after the shape of geese, and sticks two or three white feathers in the upper part, to resemble the head and neck of the blue-winged goose, which is, of all other kinds, the most numerous in the marshes I allude to. Having loaded his guns (he usually has two), he keeps a sharp look-out for game. On seeing some flying at a distance, he crouches down, and begins to imitate their call in a very perfect manner; the attention of the birds is attracted, and on seeing the decoys, they usually wheel round, and come up from leeward, either over or close to where the Indian lies concealed, and he generally secures one with each gun. If there are only two geese, a male and a female, he invariably shoots at the female first, and if he kills her, he is pretty sure to shoot the gander also, as his affection for his mate is almost certain to bring him a second time within shot.

The Indians all say that a small bird that always arrives about the same date as the Canada goose, uses this large and powerful bird as an easy and agreeable means of transport northward; and assert that they often see one or more fly away from a goose when it has been fired at. As nothing of the same kind is said about any of the other kinds of geese, I am inclined to believe the statement to be true.

By the time that the wild fowl have taken their second flight northward, the rivers are open enough for navigation, and those Indians that are strong and active, and willing to work, are engaged to form crews of boats going up the rivers with loads of goods for the inland ports, for which at that time they received much higher wages than are paid either in England or Ireland, with abundant rations. The work in ascending the stream is hard, especially on the portages, where the usual load is 180 lb., and each of the crew has generally to carry four such loads over the portage. The descent of the river is much more easy, because the lading, consisting of furs, is much lighter; and the boats are coming down stream. In the summer, there are many other services to which the Indian is put. The squaws, during the absence of the men, are occupied either in setting nets, or angling in the river, when not engaged to do some work at the Fort.

The autumn comes round, and with it, in September, appear the wild fowl on their southward migration, in much larger numbers, and many of them being young, much more easily shot than in spring. In this case the wily Indian sacrifices the mother to her affections. It is most painful to witness the efforts made by the poor parent to induce her brood, of perhaps five or six young, to avoid the fatal attraction of the decoys and imitation call of the Indian, who crouches patiently, even although the young ones are flying quite close to him, until the mother comes within shot. When he shoots her, he is pretty sure to be able to kill the whole brood, as they will not leave the place where their guide and guardian fell. The papa generally keeps out of reach, having possibly had some bitter experience of the danger of going near the decoys, and his paternal affection not being equal to that shown in the spring for his partner.

The geese and ducks, in the fine feeding of the salt marshes, become very fat, so that the Indians save up a large quantity of grease and a number of geese, boned and dried for winter use. The grease is packed in bags, made of the skins of the geese themselves.

Warned by some sharp frosts and showers of snow, both Indians and wild-fowl start for the winter quarters about the same time. The latter (especially the geese, which make very long flights without resting) prepare themselves by a few days' fasting, as is evinced by their not having an atom of food in their crops or stomachs at this time.

The Indian proceeds to the Fort, and completes his winter supplies, which he obtains, whether he can pay for them or not. These consist of blankets, one for each member of the family, cloth for a new suit of clothes, capot, flannel shirt, etc., axes, ice chisels, kettles, ammunition, twine for nets and for rabbit snaring, fish-hooks, the means of lighting fires, pipes and tobacco, possibly a small supply of tea and sugar, and a bottle of medicine. The family now proceed in their canoe or canoes—often there are two, one of which is smaller, in which the Indian goes ahead hunting—to their hunting grounds, when they at first generally locate themselves on the shores of a lake well supplied with fish, if its position is at the same time consistent with a probable good stock of fur-bearing animals, or, what is perhaps still better, a plentiful supply of rabbits (*Lepus americanus.*

Let me here say a word or two on the important place, as regards the Indians all over the country, which this little animal, the rabbit, occupies. Every nine or ten years the American hares or rabbits become very numerous, and are then attacked with a very fatal epidemic, of which they gradually die off in a few years. They are found sitting dead in their farms, usually under the spreading branches of young spruces and pines, which grow low down to the ground.* The disease spreads over many thousands of square miles of territory in the same season, although it can scarcely be communicated by contagion from one rabbit farm to another, as they are usually miles apart.

In the course of a few years scarcely a rabbit is to be seen. They then gradually increase, and in the ninth or tenth year they are again at maximum. The effect is curious. When rabbits are numerous, the Indian pitches his tent near to or in the midst of one of their favorite resorts, cuts down a number of birch and other trees, the favorite food of these rodents, on which they fatten with great rapidity. The wife and children (if any) are meantime busy making small low hedges of pine in different directions across the runs of the hares, leaving a gap here and there for them to pass through. When the hares have got in good condition, a great number of snares are set in the gaps in the hedges, and in the morning 50 hares, or perhaps more, are found strangled. While the rabbit snares are attended to by the squaw, the hunter has been building a series of marten traps, at intervals of half or one-third of a mile apart, to the distance of twelve or fifteen miles on each side of his tent, in the direction most favorable for his object, of which he judges by the footprints in the snow of the animals he wishes to catch. The lynx, marten, fox, and fisher, all congregate to feed upon the rabbits, and finding tempting baits in the traps put their heads in and get caught.

It will thus be seen that the Indian is hunting under the most favorable circumstances, having food in the form of rabbits, and furs at his very door.

I may mention that rabbit skins, when properly joined together, make one of the warmest blankets possible, by being cut into strips, sewn together to form a long line, and then loosely netted. Although the fingers may be pushed with the greatest ease through any part of this blanket, a person may pass the coldest of nights wrapped in one without the slightest discomfort. An Indian child, dressed up in rabbit skins, like "Baby Bunting," is a funny looking, but very cozy little creature.

By the way, I seldom, if ever, heard an Indian child cry;

* A paper read before the Society of Arts, London, March 21, 1882.

† I am indebted to the kindness and courtesy of the Secretary of the High Commissioner of the Dominion Government in London, for the use of the volume from which I extract the greater part of the above information.—J. R.

* About 50,000 geese, besides many ducks, all of fine quality as food, are annually shot on the shores of Hudson's Bay. A goose and pound of flour is a man's daily ration.

* The late distinguished naturalist, Sir J. Richardson, has been wrongly informed on this subject when he says that "no dead are found," and he assumes that the hares must migrate. This cannot be, as the epidemic attacks the whole range of country where the hares are to be found the same season.

certainly never heard one squall, as more civilized babies are in the habit of doing, nor ever saw one chastised. It would be thought very unnatural and cruel in a mother to flog or strike her child.

When the rabbits disappear, the Indian has either to fish, or to spend much time in hunting deer or other large animals, for food; while the fur-bearing animals have also to scatter all over the country, with the same object, and are thus far more difficult to trap, the result being that the collection of furs becomes very much diminished, wholly caused by the dearth of rabbits. This, however, has one favorable effect —the martens, etc., while scattered over the country, have time and opportunity to increase in numbers, after being, perhaps, too much reduced by the previous facility of catching them during the rabbit season. As a rule, the Indian shows as much judgment in killing the beaver on his lands as a farmer does in weeding out his stock. This he can do pretty easily, as usually the beaver is netted, and it can be seen without hurting it whether it is one the hunter would wish to kill; if not, it is let go again.*

Black and brown bears are sometimes shot, frequently snared in a peculiar manner, and often killed when in their winter dormitories, at which time they are easily knocked on the head. Not only the Crees, but all the Indians I know, treat with much ceremony and respect the body of the bear they have killed. He is placed in a sitting posture against a tree, and long speeches are made of apology and regret for having been under the disagreeable necessity of killing him. A somewhat similar ceremony is gone through by the natives of one of the northern islands of Japan (Yesso, I think), when a bear is killed, and a feast held. My authority for this is, to the best of my recollection, "Peoples of the World," edited by my friend, Dr. R. Brown.

As it is supposed by the Indian that even after he has been disemboweled the bear may come to life again, a piece of stick of the proper length, sharpened at both ends, is placed in his mouth, keeping it wide open, so that he cannot possibly close his jaws. For this additional indignity a profuse and humble apology is made to Bruin. I believe the supposed necessity for this precaution arose from the fact that a bear, thought to be dead, came to life again while being carried home, and took a mouthful out of one of the Indians carrying him.

Having alluded to a fishery as a means of obtaining food, I may mention that a good large lake, well-stocked with white fish (*Corigomes albus*), is the most safe and sure source of food supply in America. Deer, buffalo, and rabbits may fail, but a good fishery seldom or never does so. I have thus dwelt rather lengthily on rabbits and fish as an article of diet to the Crees, because it applies equally to all tribes of Indians, south of about latitude 60° north, and is, therefore, a question of great importance to them.

The fur-bearing animals found on the lands of the Crees are the black and brown bear, the white bear, near Churchill, the wolf, fox † (cross, red, and black), the lynx, fisher, marten, otter, musk, and musk-rat, and also the wolverine, which all trappers, whether Indian or white men, would wish to see exterminated. Unless the Indian runs short of something particularly requisite for use, he does not visit the trading fort during winter, but brings in all his furs in the spring, as already mentioned.

As may be inferred from what I have already said, the Crees are a fine, docile race, with comparatively few faults, and these are injurious only to themselves. They are very fond of strong drinks, and have a very great dislike to agricultural labor on their own account, although they work very well for others when paid for it. They used, in old times, to have some rather unamiable weaknesses, which were put a stop to by the Hudson's Bay Company. One of these was, that when any of the tribe became old and unfit for work, his relatives, with, it is said, the sanction of the victim, had his life cut short by the use of the cord. The process was to take the aged hunter out of his tent, giving him a pipe of tobacco, and place him in a comfortable seat, while, close to his feet, a grave was dug. When this was ready, the affectionate relatives, with less ceremony than they used toward the bear, applied the cord, and as soon as death took place lifted the body into the grave, and covered it up. There was another practice, which was more easily stopped, but in a different way from that mentioned above. A band of "braves" used to assemble each spring, and being well armed with guns, proceeded to kill Eskimos at some fishing stations of these people on the East main coast; this was called the "Eskimo hunt." The plan adopted by the company was to supply with guns the Eskimos, who formerly had only bows and arrows and spears; and nothing more was ever heard of the "Eskimo hunt."

*(To be continued.)*

* I read somewhere, the other day, that the beaver lies dormant during winter. This is a mistake, as he is wide awake, lively enough, and in fine condition. He would not think of laying up such a large supply of winter food if he was to be dormant.

† Strangely enough the red, cross, and black foxes are all found in the same litter, the black variety being always the least numerous, but ten times more valuable than the red.

## MAN AND NATURE IN NORTHERN ALASKA.

MR. E. W. NELSON, who returned from Alaska a few months ago after remaining four and a half years in Northern Alaska for the signal service, has just made a preliminary report of his work and of his proposed publications.

Mr. Nelson secured an unbroken series of meteorological observations covering the time he was in Alaska, and the report on this will make part of the report of the Chief Signal Officer for 1881.

A more careful study, however, is to be made of the data obtained and of additional material, and a new paper prepared. Combined with this will be a paper on several new points of importance in the physical geography of the region. Mr. Nelson traveled extensively over parts of the country that had never before been visited by travelers, and traced the course of many heretofore unknown streams, located lakes, bays, and mountains that had never been heard of, well enough at least to give future surveying parties guides that they otherwise would not have had. Some of the most interesting of the information gathered by Mr. Nelson was obtained from the Esquimaux, and relates to the ethnology of the race. He brought back an extensive and complete series of specimens, among which are about nine thousand implements and carvings, illustrating the mode of life of these people and their handiwork. His notes of their customs, the vocabularies, and his collection of photographs are very interesting and important, and General Hazen proposes, if Congress can be induced to make the necessary appropriation, to publish a series of valuable papers on the discoveries, for which Mr. Nelson is now preparing the manuscript. The papers will form a very important contribution to ethnology, and will add an interesting chapter to the history of North American aborigines. Mr. Nelson has about thirty-five hundred ornithological specimens, with full notes and sketches of the brightly colored parts of little known water fowl. This material will be used as a basis for an elaborate contribution to the history of Arctic and sub-Arctic birds which will describe all the species known to Alaska. Many of these species have never been described in an American work on ornithology, and some are new to science. It is proposed to accompany this work with beautiful illustrations which will add materially to its value. This part of the work is very nearly completed. The manuscript of the ornithology will be ready for the press early in June. Another part of the work will consist of a detailed account of the mammals of the Territory, with special reference to their distribution and abundance. Mr. Nelson has brought back several hundred specimens, and has full field notes with which to illustrate this comparatively unknown subject. The large number of fishes and the notes upon their numbers and distribution will make the ichthyological report one of great practical as well as scientific value. One of the most important features of the fish report will be the series of sketches representing the life colors of some of the most important varieties.

[Continued from SUPPLEMENT 345, page 5496.]

## THE PANAMA CANAL.

By MANUEL EISSLER, M.E., of San Francisco, Cal.

### III.

### THE ISTHMUS OF PANAMA.—TOPOGRAPHY AND GEOGRAPHY.

THE Isthmus lies between 8° 50′ to 9° 20′ northern latitude, and 81° 50′ to 82° 20′ western longitude, and is one of the principal contractions of the immense arm of land which unites the two continents of America, is 2,300 kilometers long, and extending from the Isthmus of Tehuantepec in Mexico to the Gulf of Urabadans in the United States of Colombia.

The Isthmus of Panama is 56½ kilometers wide from the Bay of Limon on the Atlantic side to the mouth of the Rio Grande on the Pacific side. It takes the second rank as to the minimum altitude of its passes; of all the passes on the Central American Isthmus, the lowest one is at Guiscoyol, between the Lake Nicaragua and the Pacific Ocean. This is only 46 meters above sea level, but there the distance from shore to shore between San Juan del Norte on the sea of the Antilles and Brito on the Pacific Ocean is 291 kilometers; besides, the presence of Lake Nicaragua high above the sea level forbids the digging of a sea level canal.

On the Isthmus of Panama we find the two great conditions for the digging of a level canal—that is, a low watershed separating two rivers, of which one, the Chagres, empties into the Atlantic and the Rio Grande into the Pacific, and furthermore, we can consider the small Rio Obispo (whose bed is also utilized by the canal) as a sort of connecting link between those two rivers, leading up to the Culebra Pass, 87½ meters high, which will be the deepest point of the great open cut of the interoceanic canal; and consequently the canal takes the valleys of these two rivers, which have to be connected by a cut about 9 kilometers long.

As mentioned before, the narrowness of the Isthmus of Panama, the feeble height of its hills, the river Chagres with its large valley, present natural facilities for communication which are not to be found elsewhere on the American isthmus, and have predestined this narrow Isthmus of Panama to become the route of exchange between the shores of the Atlantic and the Pacific Ocean.

Ever since the remote epoch when the Indian population established itself in Central America, these favorable conditions and the fertility of the land attracted to the regions of Panama powerful and relatively civilized Indian tribes. Their rude commerce, then, could not chose a better interoceanic route. The Chagres opens at its mouth an excellent port for the pirogues of the Indians. The river is large, deep, quiet, and they could ascend in their canoes to the bend of Matachin, where the Chagres is only 22 kilometers from the Pacific shores, and from there they carried their burdens on easy trails, and could reach in one day's journey the sure and quiet Bay of Panama. At the extremities of this route naturally sprang up two important Indian villages. Even before the discovery of America, these towns were without doubt the centers of important native commerce, whose riches excited the cupidity of the Conquistadores, who were established, after discovering this continent, at Santa Maria la Antigua, near the mouth of the Atrato. Since 1518 it was noticed that they despised the conquest of the region where they were encamped, and under the orders of Davilla, the hangman of the noble Balbao, they leave their camps in the marshes of the Atrato to conquer Panama. That town was situated then to the east of the present city, and most likely on the same spot where the Spaniards built their strong fortifications afterward.

The conquest of Peru, Chili, and Ecuador brought a considerable number of adventurers across the Isthmus of Panama. To answer to the needs of the increased traffic the Spaniards laid out routes, of which two led to Couces and La Gargona on the Chagres. Progress in navigation soon created ships of greater draught.

The anchorage of the Chagres became insufficient, the port of Porto Bello, large, deep, and secure, soon replaced Chagres. Two routes, one of which was paved, connected Porto Bello to Panama, a town which for several centuries was the most important port on the Pacific coast.

Already then the Spaniards thought seriously about the opening of an interoceanic communication, and studies were made, but the insufficency of their technical means, and more especially the decline of Spain, prevented the execution of the work.

At the commencement of this century, after the proclamation of the independence of the Spanish Colonies, the interest of the entire commercial world concentrated itself on that point. A great many projects were made on the American isthmus; but whatever hopes were based on these different projects, the thorough studies made in late years have had for result either a *canal with lift locks across Nicaragua*, or a *sea level canal at Panama*. I should also mention here that the first researches on the isthmus were made in 1829, by an English officer, Mr. Lloyd, and Mr. Fallmore, a Swedish officer, but their labors were very limited.

The first serious study of a canal project was executed in 1843, by the Frenchman, N. Garella, chief mining engineer. He made the first triangulation of the isthmus between Chagres, Panama, La Charrera, and the Cerro Trinidad.

Speaking of low passes, the impression prevailed for a long time that the Darien isthmus offered better opportunities, as M. de Lacharmes's barometric observations had created the opinion that the Darien isthmus offered a depression of only sixty meters. But the exact measurements and explorations of Messrs. Wyse and Reclus in those latitudes have demonstrated that the pass of Tibule is not less than 142 meters high, and the pass of Tulegua 146 meters. If we consider the Isthmus of Tehuantepec, we find the lowest pass at Tarifa is 230 meters high.

The Isthmus of San Blas is a very narrow neck of land, and consequently great hopes were based upon this pass, but the high mountains there offer no low passage, and the barometrical measurements show the lowest depression to be 300 meters, and besides there is interposed between the two oceans a solid mountain chain 15 kilometers wide.

Therefore, comparing the different altitudes at these principal contractions of the great Central American isthmus, who should doubt any longer that the Panamanian isthmus is the one most proper and designated by nature for a sea level canal?

Topographically considered, the Atlantic side in the neighborhood of Colon is very marshy and low, and the seashore for two miles in length is covered with mangrove trees and often bordered by a deep belt of coral reefs.

The Pacific side is more elevated. The Cerro de Cabras, 500 meters high, the isolated peak of Ancon, 170 meters high, rise right out of the Pacific Ocean. These two abrupt hills are cut through by the mouth of the Rio Grande. The gap which this river has traced for itself to bring its waters to the ocean is very narrow, but back of this narrow pass extends a low valley 4 to 5 kilometers wide.

*Islands.*—The Bay of Panama is studded with numerous islands, forming two archipelagoes—one the Tabogas, and the other composed of the islands of Calebra, Naos, Perico, and Flamenco.

*Mountains.*—With the exception of the valleys of the Chagres and Rio Grande Rivers, the country between Panama and Colon has no other large plains or plateaus, but chains of hills, or isolated peaks, domelike hills or mounds, with natural following irregularities.

There is really no elevated mountain chain here, and it is also a mistaken idea to suppose that the chain of Cordilleras stretches its vast hills across the isthmus; the main Cordillera breaks off before reaching the isthmus.

From the group of mountains which rise to the north of the town of Santiago, in the province of Veragua, a mountain chain called the Cordillera of Veraguas separates itself to the east. This Cordillera, which is from 500 to 600 meters high, approaches gradually the Pacific coast, and ends abruptly with a height of 1,500 meters in the Cerro Trinidad, which dominates the coast of Chamé, in the Gulf of Panama.

The great Cordillera breaks off there and is not reformed on the Pacific side, but springs up again on the Atlantic side. Near Porto Bello the Cordilleras begin again, extending to the mouth of the Atrato, where they end, their heights reaching sometimes altitudes of 1,300 meters. No passes lower than 150 meters are found in this portion of the main Cordillera, and these are found 350 kilometers further south on the Darien Isthmus, between the basin of Paya, tributary of the Tuyra, and the Caquirri, tributary of the Atrato.

This Cordillera has no special name, although the mountains are well characterized. After starting at Porto Bello, it is called successively Sierra de Santa Clara, Loma Grande, Cordillera de San Blas.

From the central point of Santa Clara starts the mountain chain running parallel to those of the Trinidad group. Between these two systems of mountain chains the valley of the Chagres is formed, in which this river flows, not very wide, but very deep at Matachin, where the same attains a depth of 12 meters.

We find that the easterly mountain chain which prolongs itself from its starting point, the Cerro Trinidad, crosses the isthmus obliquely, and joins the Cordilleras of the Atlantic, about 50 kilometers east of Porto Bello. It is this small chain of hills which forms the watershed between these two oceans, and where the pass exists which the railroad has utilized, and of which the canal will also take advantage.

The highest peaks of the isthmus are fortunately all outside of this watershed and away from the axis of the canal.

As the configuration of these mountains is of importance for the understanding of the *tracé* of the canal, I will repeat their course somewhat more in detail:

From the mountain chain of Santa Clara, which rises south of Porto Bello, numerous branches radiate to the south and southwest. At the Cerro Trinidad, the extreme point of the main Cordillera of Veraguas, several branches also open, fanlike, diverging between north and northeast. The most northern borders to the west the basin of the Chagres, including also the valleys which are watered by the tributaries of the Chagres, and runs parallel with the chain radiating from the Sierra of Santa Clara. Between their slopes they leave a valley, which is very narrow and so low that at Matachin, 35 kilometers from the Atlantic coast and 22 kilometers from the Bay of Panama, the bed of the Chagres is only 14 meters above sea level.

The most eastern mountain chain, which is detached from the Cerro Trinidad, stretches obliquely across the isthmus from southwest to northeast, and joins the Cordillera of the Atlantic about 50 kilometers east of Porto Bello.

After leaving the Cerro Trinidad, this mountain chain shoots out in abrupt hills, which take the names of Cerro de Yaya, Cerro de Espave, Cerro de las Piedras, Cerro Potrero del Arado, Sierra de Ahogayegua, Cerro de Paja, Cerro de los Hermigueros, Cerro Gordo, Cerro de la Culebra, Cerro de la Mitra, Pinon Grande, Altos de Maria Henrique, Cordillera de Pacora, which are the names of the principal peaks.

These form the main watershed, and outside of the mare other high summits. On the northern declivity is the Cerro Grande and Cerro Gomboy, of which the principal peaks are 300 meters high, and on the southern declivity the Cerro de Cabras over 500 meters altitude.

The form of all the summits of the isthmus approaches a certain type, which resembles isolated peaks or domes. The sides are steep, and the whole region is cut up into a multitude of ravines and depressions.

When we contemplate from one of those peaks the marvelous country which spreads out before us, it resembles a chaos of high green mounds, domes, and peaks, which reminds one vividly of Humboldt's description of the volcanic domes of Mexico and Central America, where he calls them *Trachit Kegel*, and points to their volcanic origin.

Among this chaos of hills, which rise up between the Altos of Maria Henrique to the east and the Cerro Trinidad to the west, Dr. Maritz Wagner believes that he can discern a circular constellation of hills, having their origin in annular elevation. He seems to be able to form a connection between these peaks around some central point, and to the basin so formed he gave the name of *Kesselthal*, and he

naturally supposed that these summits arranged in a circle were the old craters of extinct volcanoes—most likely taking his views from Von Humboldt, who found in Central America plenty of places where the aspect was similar and where these domes (Sturtzkegel) proved to be extinct volcanoes; but the late explorations of the isthmus have proved their origin to be due to entirely different geological causes.

The soundings and shafts have, beyond a doubt, within the last few months established the fact that the portion of the isthmus wherein the axis of the canal lies has been covered up with the products of submarine volcanic action, and that these domes were the result of a subsequent elevation, and although they are these same Trachyt-Dolerit Kegel, of which Humboldt speaks so much, they have not been the seat of volcanic activity, as nowhere on the isthmus eruptive products of terrestrial volcanoes are to be found. The existence of lavas, volcanic ashes, pumice stone, obsidian, is only manifest to the south, in the Cordillera of Bando, in the northern part of the province of Veraguas, at the foot of the extinct volcano of Chiriqui.

But, on the contrary, everywhere there are evidences of products from submarine volcanic action, and in the soundings which have penetrated this submarine volcanic flow some very interesting facts have been brought to light. It is through the decomposition of this great layer of submarine lava which forms now a great portion of the hills through which the canal will have to be cut, that deep strata of clay have been formed. The clay is nothing more nor less than decomposed volcanic mud, in which we find embedded different sized blocks, from small nodules to pieces weighing tons, of the original matrix in a perfect state, but giving the best evidence of how these deep beds of clay were formed, which at some points at Culebra Hill had reached the depth of 33 meters without encountering the solid formation as yet.

The rocks are nearly all of a volcanic nature, such as trachyte, dolerite, basalt; some sandstones and limestone are also met with, and they are easily classified as to their hardness. They are most compact in the center of the isthmus, and diminish in hardness in proportion as the two oceans are approached. In the valleys there are large zones of earth, clay, and alluvial deposits.

RIVERS.—The river Chagres drains the northern portion of the isthmus. This river takes its origin about 50 kilometers northeast from a straight line down, joining Panama and Colon. Its upper course runs parallel to that mountain chain spoken of, the last remnant of the great Cordillera, and in its upper course passes through narrow gorges and enters large flat basins, which in former times were lakes, and in the building of the canal these basins or beds of ancient lakes will be put to good use again, by a system of dams, or by a large dam they will be converted into artificial lakes, to retain the overflow of the Chagres River during the floods which may occur during the rainy season.

This Chagres River, which drains the Atlantic slope of the isthmus, takes its source in the nest of mountains formed by the meeting of the Cordillera of Pacora with the Cordillera of the Atlantic, about 50 miles to the east of Porto Bello.

This basin has for its limits, to the west, a mountain chain running out from the Cerro Trinidad, sloping off near the mouth of the Chagres under the name of Sierra de Pina. The basin is bordered to the south by the main watershed, to the north by the Cordillera of the Atlantic, and the prolongation which reaches to Gatun.

The surface of this basin is 2,650 kilometers square, and its greatest length from east to west is 100 kilometers, and its greatest width is 50 kilometers.

In his upper course, the river follows a southwest direction, and receives several tributaries, of which two, the Pequeni and the Chilibri, have a certain importance. In his course he passes some narrow gorges, of which the principal ones are those of La Campana, which are found in front at the affluence of the Chilibri near Cruces, and one near Matachin. Then the Chagres receives as affluents the Rio Gatuncillo, Rio Caravaill, and Baila Monos. Near Matachin the river takes a westerly course; at Barbacoas, where the river is crossed by an iron bridge, he changes his coarse to northward and pours his waters into the Atlantic near the Hamlet Chagres, a dirty little town. That last portion of its course is in low lands with slight undulations, where impenetrable forests change with prairie lands.

From Barbacoas on the valley gets larger. Below Tabernilla to Buena Vista extend large plains, covered with thick forests. Numerous rivulets drain sufficiently the rains.

The real marshes are only 11 kilometers long, extending from the confluence of the Rio Trinidad along the Rio Mindi.

The tributaries which the Chagres receives after leaving Barbacoas are, on the right side, the Frijole Grande, the Frijolito, Rio Agua Salud, and the Gatun, which drains a basin of 420 square kilometers.

On the left side, the Chagres receives the Caño Quebrado and the Rio Trinidad, whose basin is 420 square kilometers.

All these affluents, with the exception of the Trinidad and the Gatun, are only torrents which become dry in the summer season.

Near the ocean, the plains become marshy, and in front of the river Trinidad, one of his main tributaries, there are some stagnant large ponds united by trenches covered with marine vegetation.

Beyond the mouth of the Gatun, the second largest tributary, there are some more lagunes, and during the dry season these inland morasses dry out almost entirely.

In the middle portion of his course, the Chagres forms sometimes some rapids, and in other places there is hardly a current noticeable.

From Trinidad to the ocean, his waters are so stagnant that the tides of the Atlantic produce a very noticeable counter-current, which reascends the river quite a distance. His depth ranges from 4 and 5 to 12 meters.

From Matachin to Trinidad the Chagres is from 50 to 80 meters wide, in front of Trinidad from 60 to 100 meters. This river has been gauged on various occasions.

The floods of the Chagres are mainly caused in part by the backing up of the water from below. Much of this could be prevented by clearing off the timber in the bends of the river.

Garella has gauged the Chagres at Gargona, and has found its delivery equal to 19 cubic meters per second; this was on the 26th March, 1843, the end of the dry season.

The 30th January, 1875, at a time when the river falls, Mr. Menocal, engineer of the American expedition under Commander Lull, gauged the river in front of Matachin, giving him a result of 29 to 30 cubic meters per second.

The 15th of March, 1875, at a time when the water is very low, a second gauging in the same place gave the same engineer a result of 18 cubic meters per second.

The 8th of April, 1878, at Mamei, at the end of the dry season, the gauging of the Chagres gave 18 c. m., and having been an ordinary season, this can be considered the minimum flow.

In January, 1875, the Chagres was gauged with a delicate current meter for testing velocities of currents, and the daily discharge was found to be 87,350,400 cubic feet; at this rate it would take a long time to fill up the space behind the great dam at Gamboa, which no doubt will be able to hold back the greatest overflows.

As to the overflows of the Chagres, which are enormous at some seasons, it is the opinion of most engineers who have studied this subject, that the maximum flow at Matachin will not exceed 1,200 cubic meters per second. The average flow all the year round at that point has been put down at 81 cubic meters per second.

It is especially against the overflows of this river that the canal builders will have to guard, and it will become their foremost task to regulate this river, and become perfect masters of the same, before even any attention can be paid to the actual digging of the canal.

Mr. Reclus, in his report to the commission, also speaks of the precautionary measures which are going to be taken, by turning a large portion of the waters of the Chagres into the Pacific Ocean, by a special system of dams in its upper course. The headwaters being nearer to the Pacific than to the Atlantic, there is no doubt that through some low passes the river can be turned into new channels, which by natural courses will find a waterway to the Pacific.

The point where the overflows would be most marked is in the contraction of the valley above Matachin. The American expedition under Commander Lull reports that in that locality, according to what the natives say, the maximum height of the overflow reached a height of 11 meters above ordinary water level, and that the waters remained at that height for six to eight hours before subsiding.

It has been also noticed that during these overflows the waters of the Chagres are backed up, driven back into the Rio Obispo, an affluent.

It has been established that the waters there also rose by this accumulation to a height of 7·40 m. Altogether an increase of 11 meters above Matachin for the Chagres must be considered as a maximal figure.

RAINFALL AND OVERFLOWS.—Mr. Reclus furnishes the following items as to the rainfall: After a rainfall of 0·18 m., the augmentation of the flow in the Chagres River, near the mouth of the Rio Trinidad, would be 486 cubic meters on an average during eight days, and the maximum flow may reach 936 cubic meters.

After a rainstorm of 0·15 m. the augmentation may average 385 c. m., and reach a maximum flow of 770 c. m.

For a rainfall of 0·100 m., 0·075 m., 0·050 m., 0·025 m., the augmentation would respectively be 256 c. m., 192 c. m., 128 c. m., 64 c. m., but the maximum flows at the start may reach 512, 384, 256, 128 c. m. respectively.

Only once or twice a year would there be a flow of 400 c. m. after what has been enumerated above. And the flows of 800 to 1,000 c. m. are only exceptional cases.

In November, 1879, the Chagres rose in one night 40 feet. Mr. Menocal, of Com. Lull's expedition, points out in his report also that the Chagres rises 30 to 35 feet. It shows that in the upper part of the Chagres and its confluents the surrounding hills are abrupt, and how little the soil absorbs after once the rainy season has set in and the earth has once been impregnated with a certain quantity of water.

It can be estimated that the annual rainfall may vary from 80 to 150 inches, which no doubt is something enormous.

It is also a noticeable fact that the rainfall is heavier on the Atlantic than on the southern or Pacific Slope.

Like in all tropical countries the year is divided into the summer or dry season and winter or wet season. The heavy rains set in about the middle or end of May, and last till the end of November. There are days and sometimes weeks when it does not rain at all, and sometimes it rains only during the night.

The north winds commence generally in December, and bring along the fine weather, which lasts till the end of April and part of May.

These five or six months are the summer season, but once a while a rain shower may occur.

METEOROLOGICAL OBSERVATIONS.—Some meteorological observations may be of interest, especially those taken by the Canal Company in 1881.

As mentioned before, the greatest amount of rain falls on the Atlantic slope and plains of the Cordilleras in the month of November, whereas on the Pacific side the month of October has always been regarded as the rainiest month in the year. There is no doubt the rainfall on the Atlantic coast pours down a quantity of water one-third more than ever falls over the slope and islands of the Pacific.

Annual rainfall at Aspinwall-Colon, 1869 to 1874:

| | | |
|---|---|---|
| 1869 | 114·23 | inches. |
| 1870 | 149·64 | " |
| 1871 | 99·58 | " |
| 1872 | 170·18 | " |
| 1873 | 87·12 | " |
| 1874 | 137·70 | " |

It is to be regretted that the observations on the Islands of Taboga have not been taken for the same full period.

The Canal Company have rain gauges (udometers) at their stations, which will enable them to state exactly the rainfall on the different points of the isthmus.

RAINFALL ON THE ISLAND OF TABOGA.

| | | |
|---|---|---|
| 1861 | 71·89 | inches. |
| 1862 | 48·51 | " |
| 1864 | 45·22 | " |
| Part of 1866 | 30·22 | " |

In 1861, on the 14th of April, the temperature rose to 91° Fahrenheit, highest; in 1861, on the 26th of April, the temperature stood 74° Fahrenheit, lowest, at Panama.

The solar ration rose the blackened bulb thermometer to 115° at midway on the 3d of April, and to 102° on the 26th, in the morning.

A thermometer sunk in the earth 2 feet, on the side of a hill, averaged 80° for 10 days.

The heat, therefore, is not so oppressive, and is only aggravated through the large amount of moisture in the air.

The difference in the amount of rainfall upon the windward and leeward sides of the Isthmus, approximately stated in the above quoted passages, is, of course, to be expected. Narrow as is the Isthmus at this particular point, the enormous precipitation on the windward side frees the atmosphere of a large percentage of its moisture before it has crossed the high ground.

The temperature in the shade averages 82° F. about the year round.

The following data were copied by me from observations taken at Colon by the canal company, but as far as the barometer is concerned, the same shows but slight variations, and can not be relied upon, as the atmosphere there is so sluggish that this instrument loses its sensitiveness, and does not indicate any sudden changes in the atmospheric condition, such as the approach of a storm.

In April, 1881, the barometer stood, at 6 A.M., 763·6; 1 P.M., 763·7; 9 P.M., 763·7; the absolute maximum for the month was 764·7; the absolute minimum, 761. The rainfall for the month of April was 64 millimeters. The average temperature at 6 A.M., 26·1° C.; 1 P.M., 29·3° C.; 9 P.M., 26·6° C.; maximum temperature, 30°; minimum temperature, 21·4°; the absolute maximum temperature was 34·4° C. on April 16; the absolute minimum, 20·5° C. on April 4.

In May, 1881, the absolute maximum of barometer, 763·40; the absolute minimum, 756·55. The total rainfall for the month of May was 255 millimeters. The average maximal temperature was 34·5° C.; the average minimal, 22·2° C.

In June, 1881, the absolute maximum of barometer, 760·57 on the 7th; the absolute minimum, 756·26 on the 22d; The total rainfall for June was 408 millimeters during 26 rainy days. The absolute maximum temperature was 34·3° on the 25th; the absolute minimum, 21·8° on the 24th.

In August, 1881, the absolute maximum barometer stood 760·22 on the 26th; the absolute minimum, 758·12 on the 29th. It rained during 23 days, and the rainfall amounted to 164 millimeters. The absolute maximum temperature was 33·4° C. on the 9th; the absolute minimum, 21·9° C. on the 1st.

Some calculations made before the Commission as to rainfall in the basin of the Chagres are extremely interesting. The basin of the Chagres above Matachin has a surface of 1,200 square kilometers. A rainfall of 0·15 c. m. on that surface would give a cube of 180,000,000 cubic meters, and a rainfall of 0·18 m. gives 216,000,000 cubic meters.

Mr. Reclus fixes the flow of the Chagres, at the time of its greatest height and maximum point of inundation at 1,450 cubic meters a second at Mamei, and at Gatun this figure will grow to 1,600 cubic meters, and at Matachin it will decrease to 1,200 cubic meters. Therefore, once a reservoir established which will hold 1,000,000,000 of cubic meters of water, it does not make any difference what amount of rain may fall; it will be able to retain sufficient, by having a well regulated outlet, so as to protect the sea level canal from any inundations.

On the Pacific coast are numerous small rivers, of which the principal ones are the Rio Caimito and Rio Grande.

The Rio Grande takes his origin to the west of the Cerro Culebra, and has a slight fall to the ocean. At Pedro Miguel, he reaches the low lands, and at the station of Rio Grande, he enters the marsh lands. The length of these are about four miles, and the same width. Almost everywhere is his terrain below the level of high tides. The soil is clay and sand, except at his mouth. His valley is not covered by a forest; only small mangroves grow there, and guagajas. The water flow of the Rio Grande is rather small.

PASSES.—The isthmus most favored by a minimum altitude of its passes is the one of Guiscoyol, between the lake Nicaragua and the Pacific Ocean, as the same is only 46 meters above sea level. But there, the distance from shore to shore between San Juan del Norte, on the sea of the Antilles, and Brito, on the Pacific Ocean, is 291 kilometers; besides, the presence of lake Nicaragua above sea level renders it impossible to think of a project of a sea level canal. Therefore, as to low passes, the Panama Isthmus ranks second, as the lowest pass of Culebra is 87½ meters, situated between the Rio Obispo and the Rio Grande. To the rest of Culebra are other passes, like Casa Herrera, Paja, Potrero del Arado, whose altitudes range from 120 to 140 meters.

ATLANTIC COAST.—The Atlantic coast is very high around Porto Bello, but falls off considerably from Point Garda to Point Paro, to the west of the Bay of Limon, where the high hills commence again. On some points the coast is flat and marshy, as near Colon, and for two miles there the beach is covered with mangroves, and in some points bordered with a belt of corals, which belt extends and obstructs completely the two bays of Las Minas.

PORTS.—Porto Bello is located 10 miles northeast of Colon, and is a large and safe harbor.

At the mouth of the Chagres, back of the bar formed by the *debris* of the river brought down to the ocean, opens another port, but small, and of no importance.

LIMON BAY.—The great Bay of Limon, where the canal will come out, is deep; the surface is 35 square kilometers, of which one-third has nine meters depth.

This splendid bay is beyond the reach of storms, and only in 1865 has one taken place doing damage to shipping.

Although badly sheltered, the harbor is sure; the trade winds lose all their force within a few miles from shore, and only at the commencement of December, when the dry season sets in, are there a few rough days. Outside of that nothing is to fear.

But a dike will be built to protect the entrance of the canal.

WINDS.—The winds along the Atlantic coast blow from north-east to north-north-east during the whole year, and from November to May, they become very strong on the high sea, and their direction then changes to east-north-east. During the night they moderate somewhat, especially near land; and constantly from five to ten miles off the coast they are rather mild.

In that narrow zone of five to ten miles, blow, during the summer months, variable land and sea breezes, and, occasionally, for two or three days successively, westerly breezes make themselves manifest, which are of quite great violence, and they are called vendavales, but they are favorable to ships which wish to keep away from shore.

SEA CURRENTS.—The current which coasts along the shores of the Panama isthmus, on the Atlantic side, carries to northeast, and his swiftness is sufficient to prevent the alluvial matter, brought down by the Chagres, to deposit itself outside the bar, and to there form a delta, which is contrary to what takes place at the mouth of nearly all rivers which flow into a sea with a low tide. It also lets us conclude that the deposits which the Chagres carries are small.

TIDES.—The tides on the Atlantic coast are very irregular and of little importance. In the months of August and September take place the spring tides, which are rather high, about 0·49 m. Then take place the neap tides of 0·19 m. The average tide is about 0·34 m.

BAYS.—On the Pacific side there is no such fine bay as the Bay of Limon, and they are comparatively but small land indentations, like the port of Panama, and another small one at the mouth of the Rio Grande; then there is the port of Buque, at the small bay of Vaca del Monte, where N. Garella proposed to come out with his canal.

SEA BOTTOMS.—There is very little depth to the Pacific Ocean near Panama; the depth of 10 meters, at low tide, is about two miles distance from shore; the nearest point where these depths are to be found are to the east of the islands Nao, Perico, and Flamenco. In some points great sand bars extend, which are uncovered for long distances by the low tide.

PORT OF PANAMA.—Between the point of Paitillo, a promontory of black rocks about 1¼ miles north-east of Panama, and the high plateau of sandstone, on which the town of Panama is built, there opens the shallow bay of Panama, which is nearly all laid bare at low tide, consequently only very small vessels, canoes, and bongos can make use of the same; and the large ocean steamers and deep shipping have to look for anchorage ground near the islands of Perico and Flamenco, and the Pacific Mail Steamship Company utilizes one of these islands as a sort of central depot, with shops and buildings.

WINDS.—The winds in the Gulf of Panama are regulated by the season. Nevertheless, north winds predominate during the dry season. In the south of the Gulf they are somewhat stronger, and near the coast of Veraguas, the breezes in January and February are quite strong. In April and May the earth winds are less regular; they are more westerly, with calms; a smooth sea, with land breezes; and southwest, squalls. With the rainy season in June come the south winds, which are sometimes violent; but the northwest winds appear very often in the afternoon.

Ships leaving Panama will have generally good breezes at all seasons as far south as Point Mala.

Between the Islands Galapagos and the coast, to the west and south of 5° northern latitude, the winds are between south and west all year round, excepting during the months of February to June; they are sufficiently strong to render navigation easy.

But north of the 5° latitude, between 82° to 112° longitude west, there is a narrow strip of calms, light breezes, and occasional squalls.

STORMS.—The Bay of Panama is outside of the region of storms.

SEA CURRENTS.—In the Gulf of Panama meet the Peruvian and Mexican currents, therefore the direction and intensity of the currents are very changeable there.

In the Gulf of Panama are constant currents; the one starting from Cape Lorenzo extends to a distance of 60 miles seaward, skirts the coast around the bay, and then turns south with considerable force, especially during the dry season; and in descending the western coast of the bay, it meets the Mexican current coming from west-northwest.

Generally, the current skirts the coast from east to west; however, on account of the high tides prevailing in the Bay of Panama, these currents are of a very changeable nature, and have considerable force. Ordinarily, the ebb carries to the south with a swiftness of 1½ miles, and is quicker than the tide current, which carries to northwest.

The Bay of Panama is very quiet, calm, and safe; great swells and surges are unknown here, and only occur moderately at ebb tide, and are not noticed at all at high tide.

TIDES.—In the Bay of Panama the duration of the tide is 3 hours 23 minutes, and has quite an amplitude.

| | May and June. | November and December |
|---|---|---|
| The maximum amplitude..... | 5·40 m. | 6·49 m. |
| " minimum " ..... | 2·42 m. | 2·95 m. |
| " average height of spring tide.... | 4·29 m. | 5·27 m. |
| " " " neap " .... | 2·93 m. | 3·78 m. |
| Average tides..... | 3·66 m. | 4·30 m. |

For a long time the opinion prevailed at Panama, like at Suez, about the difference of the sea level. But the nivelations executed along the railroad have proved that the level of the Atlantic and Pacific is the same; but the average level of the Bay of Panama is somewhat higher than the level of the Bay of Limon. This difference varies according to seasons, and averages about 0·20 m.

PRAIRIES OR SAVANNAS.—The regions of Panama are not entirely covered by forests; the savannas, principally on the southern slope of the main dividing ridge, form a zone sufficiently great between the forests of the coast, and those which cover the high ridges of the Cordilleras, to be taken note of.

On these small patches of prairie land, which form an agreeable contrast with the impenetrable virgin forest, grow during the rainy season different herbs and grasses. When the dry season comes, this verdure disappears, and these prairies are then covered with a smooth covering of reddish foliage. These dried up herbs and grasses are burnt up, so as to allow them to grow up again with the first rains, as here takes place the cattle raising, which is one of the principal industries of the isthmus. On the Atlantic side we see those prairies on the left hand shores of the Chagres, between San Pablo and Cruces; and in front of that village they are nine kilometers long.

The cattle there look nice and fat, and the meat I ate on the isthmus was nice and juicy.

FLORA.—The different species of plants and trees vary according to the elevation of the land they grow on; they also change according to the parallel zones to the coast, in reference to the quantity of rain which falls there.

The zone along the coast, which has a variable width, is covered with mangroves, which have such a ramification of roots; the Manchineel tree and palms, which is followed by the marshes of Mindi; and here, on large tracts, extend certain plants indigenous to the marshes of tropical climates, and on places of more elevated clay ground grows the plant called guabaja; the number of mangroves decreases, and those of palm trees augment.

As soon as we leave the inundated regions, the virgin forest commences; but the same is as yet but little embarrassed with lianes (convolvulus, a sort of bindweed); the trees which compose it belong to many different varieties. Almost all these species preserve their green leaves during the dry season. In proportion as we ascend the valley, the proportion of smaller trees which shelter themselves in the shade of the giant trees, becomes less, and the parasites and lianes obstruct the forest.

On the lateral slopes, sheltered from the winds of the Atlantic, and receiving constantly less rain, show themselves, although sparsely, trees with decrepit foliage.

Near San Pablo, where the valley turns to the east, and the rainfall is already considerably less, we meet here and there small patches of prairie land—savannas, and gradually the trees, with adhering foliage, gives place to trees which can support a long space of draught, and which require little water, but much light and sun. The thickets of lianes increase, and the high trees become more sparse. At Gorgona grow some large eatable palms (palma real). When green, the body of the tree furnishes food for the natives, which I found very palatable. On the southern slope of the Cordillera, we find only trees, which lose their leaves during the dry season. Without the verdure of the undergrowth, which is simply enormous, the numerous parasites and the different species of lianes, the aspect of the forest in summer would, in many places, offer a gloomy and melancholy aspect, the same as our forests, at home during the winter.

After having crossed the zone of the savannas, we find on the Pacific coast a littoral zone resembling the one on the Atlantic, but more profuse in manchineel trees and cocoanut trees.

CLIMATE.—As shown before, the temperature is endurable; and as during the summer the north winds cool off the atmosphere, and during the winter the rain and storms prevent the heat to become too oppressive, the climate for a tropical zone can be called supportable. It does not exercise on the Europeans that debilitating action as certain tropical climates do. The emigrants keep their health and their energies as long as they lead a regular life. A remarkable fact is that Europeans are less amenable to sickness than Creoles.

The town of Panama has never been visited by an epidemic, like yellow fever or cholera, although at the time of the discovery of gold in California, it was the rendezvous of multitudes of people from all parts of the world. This year (1881), in June and July quite a number of cases of yellow fever have taken place; but fortunately they were only sporadic cases, and the malady did not declare itself in an epidemic form, and no doubt was brought by the many ships which daily arrive there from the Antilles or from South America. Some localities on the isthmus are very unhealthy, like the low lands and marshes of Colon and Chagres. Few localities in this world have such a sad reputation.

For reasons of interest and economy the railroad company has chosen Colon as the principal seat of its offices and machine shops, and it is claimed that the company could not have been able to maintain itself in that locality with its numerous *personnel* of foreigners, if the climate had been really as bad as represented. And facts seem to prove it, as the mortality is not greater there than in other seaports of the Antilles. During the summer months, the time of the northeast winds, the climate is so agreeable at Colon that in spite of the limited accommodations a great many persons from Panama go there to spend several days to enjoy the refreshing atmosphere. That which mostly gave Panama its sad reputation were the fevers and maladies which the miners contracted in crossing the isthmus, when the railroad was not in existence yet, and when they were obliged to make the crossing in small boats for half the journey, and the rest on foot or mule back. From two to five days passed in these canoes, where no covering protected the traveler from sun or rain; then one or two days spent in a rough tramp over the slippery hills; evening without refreshing meals; the nights without comfortable couches; often obliged to wear the wet clothes for days and nights—naturally, the most vigorous constitution could not resist the absorption of the malarial effluvia under these conditions, and it is not astonishing that the emigrants contracted these fearful fevers.

The dangers of the route were also increased by the numerous highwaymen who infested the passage, and augmented the terror which this trip inspired, and helped to give still more credit to the bad reputation of the isthmus.

From what has been said, it is evident that the fevers have their seat in the swamps and marshes, but this objection falls away on high, dry ground.

A great deal has been said against the possibility of digging a canal through this country, on account of the malaria and the mortality which would ensue. The greatest portion of the work will be done on dry ground and in rocks. Employing the negroes and natives as diggers, and keeping them in good trim, by organizing a proper medical staff, and compelling them to comply to certain hygienic rules, and principally keeping them from the excesses of drink, it can be expected that their general health will be on an average equal to that of workmen employed throughout tropical countries.

The marshes may also prove better than calculated upon, and as an evidence is brought up that the marshes of Miudi are one of the localities of the isthmus where now there is the most of cultivation. The greatest portion of the work in the marshes will be done by excavators and dredges; the *personnel* will not be subjected to any fatigue, and will be protected against the sun and rain. It is, therefore to be hoped that with proper sanitary precautions, with frequent relays of men and only a short stay on board of the flat boats, there will be no necessity to sacrifice a great deal of human life in the marshes; and even on the dredges the workmen will not be exposed to the dangers of the miasmatic exhalations.

Naturally, during the building of the railroad, the work in the marshes was of another nature; the workmen had to carry burdens, drive piles, make embankments under a burning sun which roasted their heads and shoulders, while the body was sticking in the putrid mud of the marshes.

Outside of Panama and Colon, we find on the isthmus the town of La Charrera, situated in the savanna to the west of the Caimito River; it is a hamlet of some 2,000 people, mostly living in straw huts.

PORTO BELLO lies on a bay with a splendid harbor, which in former centuries was much frequented; this town of ruins now has about 1,500 inhabitants.

CHAGRES has lost its importance since the finishing of the railroad, and 1,000 inhabitants, without any means of support, people its dirty streets. Other villages are Cruces, Gorgona, Gatun—all conglomerates of straw huts, with a population occupied with banana, rice culture, and cattle raising.

## IMPROVED SILK REEL.

THE enterprising conductors of the American Women's Silk Culture Association have for some time past energetically pressed the question of silk reeling, and have purchased and experimented with several forms of such reels, some of them being new, and others imported from Italy. They have also employed for several months an accomplished Italian reeler, accustomed to reeling in Italy from her earliest youth, and skillful in all the adaptations of such devices. All of these were small hand reels, and carried two skeins only, the lateral movement essential to the proper delivery of the threads on the reel being effected by clumsy devices, and the capacity of the best of them being too small to make the work profitable. After many efforts, and the offering of liberal compensation to any successful device, several gentlemen of the advisory board turned their personal attention to the matter, and with the aid of a skillful machinist devised the reel represented on this page. This reel has so far been worked by hand at the rooms of the association, 1328 Chestnut street, Philadelphia, but it is adapted to power, and the cut given here represents it with that adaptation. It carries four skeins with ease, and has almost twice the capacity of any form of reel previously employed. The movement by hand is very light, requiring less power than any wooden reel heretofore used, whatever its size.

IMPROVED SILK REEL.

The following description of the reel, its invention and mode of operation, is by Dr. W. H. Wahl, the secretary of the Franklin Institute, and is taken from an address on silk culture in the United States by Lorin Blodget, delivered before that institution February 15, 1882, at which time the reel, and its mode of operation, were first publicly shown.

The secretary of the institute, Dr. William H. Wahl, at the close of Mr. Blodget's remarks, gave by request of the latter the following explanation of the improved iron frame silk reel lately constructed for the Women's Silk Culture Association, viz.:

A year or so ago the association, after considerable trouble, succeeded in getting a pattern of the reels which were said to be in use in France and Italy, a heavy, clumsy affair, all of wood, which stood upon four legs, like a table. After it had been in use a little while it warped, and became so troublesome to use that it occurred to some of the members of the advisory board to have a mechanical reel constructed of metal, which would work more accurately, and represent in an improved form the best ideas we had upon the subject. This was finally decided upon, and, after some consultation, the speaker was requested to secure the services of an expert machinist to construct such a reel. Mr. Hugo Bilgram, a member of the institute, was requested to undertake the work, and the result of his intelligent comprehension of the subject you see in the admirable, light, easy, and rapid running reel, which I take pleasure in showing you this evening, and which I believe has been found eminently satisfactory. It is constructed entirely of metal; it is very light and compact, and is devised in such a manner that it can be closed together in very compact form when not in use, or when it is to be removed from place to place. While there is no radical departure in its construction from that of the old forms of the hand reel, the new machine appears to embody every desirable feature that a hand reel should have.

The silk is wound upon the reel, the motion being communicated to the reel by hand. The driving wheel is grooved, and motion is transmitted to a smaller grooved pulley on the shaft of the reel, the proportions between driving and driven pulley being as 4 to 1. The traverse which effects the crossing of the strands on the reel is given by an open cam on the driving shaft. This engages with a bell-crank lever, connected with a brass sleeve upon a cross bar above, which slides back and forth with the motions of the lever arm. The guides through which the silk threads pass to be wound on the reel are attached to this sleeve, and they are thus given the required crossing.

The reel works with great accuracy, and without jar or lost motion, and it has proved to be most satisfactory as a first effort to construct such a machine in metal.

The skilled reeler employed by the association is enabled to reel more than double the quantity of silk upon this than upon the old wooden reel, a result highly gratifying to the association, and one that has a very important bearing on the question of the profitable reeling of silk by hand in the United States.—*Textile Record.*

## AUTOMATIC BOILER FEEDER AND CONDENSO FEED WATER HEATER.

### FROMENTIN'S SYSTEM.

AMONG the various questions connected with the care of steam generators, there is one—that of water supply—which is prominent above all others, because on account of the irregular operation of the feed apparatus there may result the greatest troubles and most dangerous accidents. And yet, notwithstanding this, the means employed for keeping up such supply in an efficient manner have made but little advance in comparison with the improvements of all sorts that are being introduced into boilers for the purpose of producing steam as economically as possible.

The apparatus in general use at present for feeding boilers are the feed pump and the injector, two devices which are not capable of feeding with water whose temperature is above 45° or 50° C.

The pump necessitates valves, pistons, packing, etc., all of which are things subject to damage. The injector, which appears to be much simpler, is variable, and quite often fails to do its work. We shall not dwell longer upon the advantages and disadvantages of these two types of apparatus, although we have deemed it not without interest to recall them briefly, in order to show better the superiority of the devices that have been invented by Mr. Fromentin for the purpose of feeding stationary boilers and locomotive boilers—the first being an automatic water feeder of constant level, and the second a condenso feed water heater. We shall briefly describe these two apparatus in succession.

1. *Automatic Water Feeder of Constant Level.*—This apparatus, which, as we shall see, is very simple, permits of feeding with very hot water of a temperature of 95° or even 100° C.

Being deprived of the movable parts that are met with in other apparatus of the same kind, the Fromentin feeder is not subject during operation to the wedging of the parts against one another, owing not only to the effects of dilatation, but also, and more especially, to the agglomeration of calcareous deposits.

It has sometimes been said that automatic apparatus have the disadvantage that they allow the enginemen to go to sleep, or to have their attention diverted. To answer such an objection Mr. Fromentin had the foresight to provide the apparatus at first with an alarm bell, which rang at every reversal of the flasks, while at the same time a whistle blew. This, however, was a needless precaution, for the oscillating motion of the flasks, as well as the slight noise produced by the rumbling of the steam in the piping at the moment of reversing of the apparatus; are more than sufficient to keep the attention of the engineman on the alert.

The Fromentin apparatus consists essentially of two copper flasks (Figs. 1 to 4), A and B, which in form remind one of the Hall pulsometer, and which are supported by two lever arms, C and C', of hollow iron, arranged according to the angle calculated for the reversal of the flasks. Two slightly conical circular plates, D and E, arranged vertically, one against the other, are held in contact by a counter screw, V, which is tightened up in such a way that there shall be no leakage. One of these plates, E, is fixed to the bed plate of the apparatus, and receives all the distributing piping, to wit: The steam port, F, the port, G, the water entrance, H, and the flow-back, I. The other, D, is movable, and is bolted to the arms, C and C', which support the flasks. The movable plate carries, in addition to those of which we have just spoken, the pipe couplings, J and K, to which are fixed the pipes, L and M, which terminate at the upper part of the flasks, and in which circulates either the steam or the water flowing back from the boiler. In no case can the flasks be in equilibrium, as there is always one filling up while the other is emptying into the boiler. Their reversal, effected through the weight of the water, is such that its effect has to be moderated by two cylinders with pistons, *n n'*, located in the bed plate.

The distribution is circular, and it is as a consequence of the alternate tipping of the whole affair as it oscillates on the single axis, O, that the distributing orifices of the movable plate place themselves alternately one in front of the other. The orifices for the passage of air are uncovered by two small screws, P and P', which are situated at the upper part of the flasks and can be unscrewed at will. These permit the apparatus to work while cold to fill the boilers before they are put under pressure.

In order to study the operation of this apparatus we shall use the four figures above referred to, along with Fig. 10, which represents one of the feeders mounted on a Farcot boiler in the Chaillot Municipal Works at Paris.

Let us suppose the two flasks are filled with water, and that the orifice of the plunge pipe, 2, is reached by the normal level. When, as a consequence of the transformation of water into steam, the water level lowers beneath the orifice of this pipe, the steam passes freely thereinto and goes successfully to the pipes, F and K, passing as it does so through the corresponding distributing orifices, F' and K', and comes, through the pipe, L, to establish an equilibrium in the pressure at the upper part of the flask, A; the latter, in its now reversed position, being in communication with the boiler through the lever-arm, C, the back flow-pipe, I, and the corresponding apertures, I' and I'. The water from this flask, after following the course that we have indicated, and passing through the pipe, T, goes to the boiler. The flask, B, under the action of the excess of its weight over that of the nearly half empty flask, A, will then gently descend and take the position that its mate at first occupied. The distribution is then reversed, and the steam, in order to reach the flask, B, will always pass through the pipe, F, and then through the pipe, M, to go to press against the water contained in the flask, B, etc.

Now while B is emptying the steam contained in A at once condenses if the feed supply is effected by cold water, but will go to be condensed in the water of the hot-water well if the feed is effected by hot water. On the other hand, the water in the hot-water well enters the flask, A, through the pipes, J and H, and the orifices, H' and I, of the movable plate. In measure as the flask, A, fills (in cases where the feed is effected by hot water) the steam contained therein is forced back into the hot-water well, and escapes then through the pipe, L, the joint, K, the corresponding aperture, K', the aperture, G', of the pipe, H, and finally through the pipe, 3, leading to the feed-water heater. To make this mode of distribution better understood it must be remarked that the orifices, G and G', to the left and right of the stationary plate, are respectively common to the coupling, G, of pipe 3 (Fig. 10), for up, and to that of the water supply, H, for down. On another hand, if we suppose the movable plate, D, applied against the fixed one, E, the orifices, J' K' and I' I', of the former will place themselves alternately, one of them opposite the steam port, F, and the other opposite the coupling, G, of pipe, 3, for up; and for down one of them opposite the back-flow, I, and the other opposite the supply pipe, H, and so on at each reversal. The operation continues thus for each reversal of the flasks up to the moment at which the plunge pipe, Q, becomes immersed in the water. At this instant the surplus water, rushing into the pipe, intercepts the flow of steam to the flask, and thus occasions at once a difference of pressure which immediately brings about a return of water, with a circulation which is so much the more active in proportion as the condensation of steam has taken place quicker in the flask under the action of such very return of water.

The joint between the plates, D and E, has no lining, its tightness being due to the continual polish of the surfaces through friction against each other, and which becomes the more perfect the longer the apparatus works. The few drops of water flowing from the condensation of steam follow a groove in the stationary plate and run into a small vessel, *v*, from whence two pipes, *u* and *u'*, carry the water to the cylinders, *n* and *n'*. Moreover the action of the boiler pressure, which tends constantly to separate the two plates, is such that the motion of these is effected without the least friction.

The apparatus is started in the following manner:

The water-supply pipe being open and the flasks filled, the cock of the steam port is first opened, then that of the back-flow, when the apparatus will at once begin operating according to the requirements of the boiler.

The apparatus is discovered to be properly regulated, by the uncovering of the orifices, when the datum points of two small projections cast on one of the plates are directly opposite one another.

This apparatus may also be used to measure the water supplied. For this purpose it is only necessary to determine the quantity of water which flows from the flask at each reversal; this being done very simply by pouring cold water on the flasks, when, through the evaporation of such water, a very well defined line will appear, which will mark the level of the water within. The number of reversals is totalized by means of a counter arranged on the bed-plate. The calculation of the quantity of water evaporated becomes easy, it being only necessary to multiply the volume indicated by the flasks by the number of reversals shown by the counter. The apparatus shown in the figures is the one now in operation at the Chaillot Hydraulic Works, and which, on the 25th of April last, had fed the boilers for 950 days without having necessitated any repairs or any cleaning. It corresponds to about a 100 horse-power, and discharges 2,000 liters (440 gallons) per hour with reversals of about 75 seconds interval. At Bourgin & Co.'s works, at Courbevoie it has given about 3,000 liters (660 gallons) per hour, with reversals of 45 to 50 seconds interval.

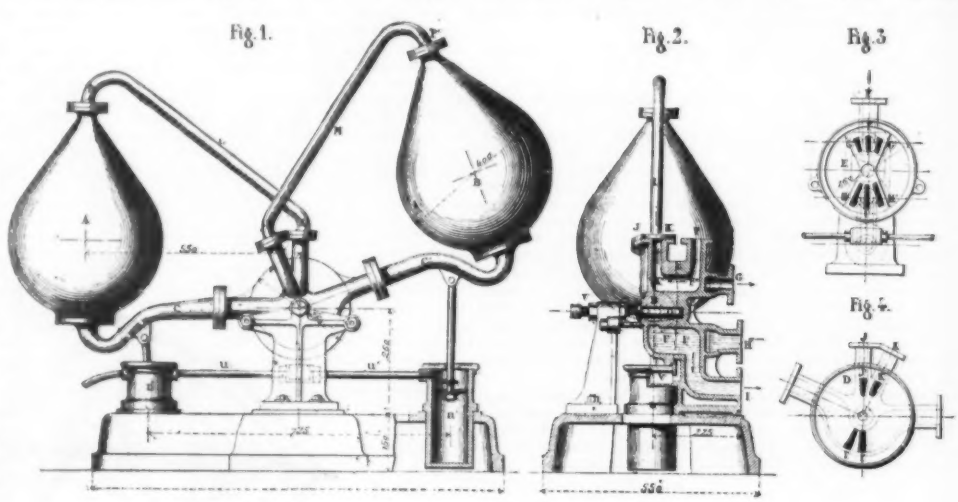
The diameter of the flasks is 470 mm. (19 inches), and they hold about 60 liters (13¼ gallons) of water. The section of the distributing ports is 0·0007 square meter. The diameter of the pipes 2, 3, and I, is 0·045 meter, and that of the plunge-tube of pipe 2 is 0·025 meter.

Before entering upon a description of the condenso heater, it will perhaps be well to dwell upon the fact of the constant water-level in the boiler, as this is the chief and distinctive feature of the apparatus under consideration. We have already shown how it happens that the level keeps constant in the boiler, and it now only remains to point out the numerous advantages resulting therefrom. These are: a constant and regular tension of the steam; an equal degree of temperature and tension in the shell of the boiler; and an always constant temperature (120° to 135°) of the feed water, by reason of the continuous return of water to the flasks from the excess in the boiler. Such temperature, moreover, is always proportional to that of the water in the boiler.

As for the return of water, that presents some very important advantages, such as the cleaning of the flasks and of all the conduits which connect them with the boiler, and the heating of the feed-water in the flasks to a temperature such that the calcareous salts held in solution are precipitated in the form of mud, provided the water has not been first purified in the feed water heater.

From the standpoint of economy of fuel and absence of chances of accidents resulting from feed, this apparatus, so simple in its construction, seems called on to render the greatest service in the industries.

II.—*The Condenso Feed-Water Heater.*—Since the apparatus just described can be applied practically only to stationary boilers and to marine ones, the inventor has, in order to give locomotives the advantages of his system, constructed a special apparatus called a "Condenso Feed Water Heater," which, although it has not as yet been applied to



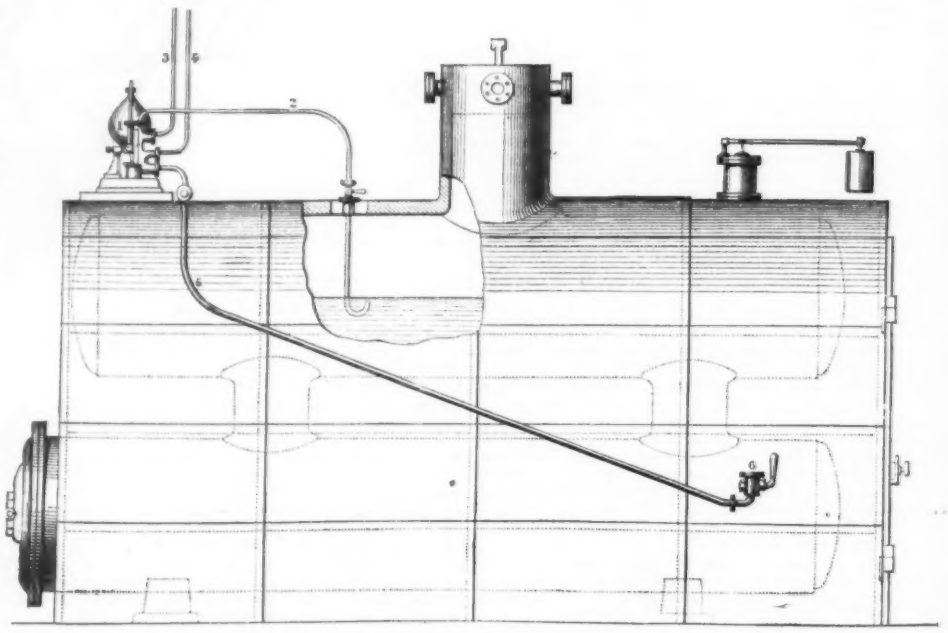



FIG. 10.- APPLICATION OF THE FEEDER TO A BOILER AT THE CHAILLOT WORKS.

FIGS. 1 TO 4 AND FIG. 10.—FROMENTIN'S AUTOMATIC BOILER FEEDER.

railway locomotives, has given most favorable results on a movable boiler.

The apparatus consists essentially of a chamber, A (Fig. 5), called the feed-water heater, cast in a piece with another one, B, of the same flask shape as those of the feed-water apparatus. At the side of this latter there is arranged a slide-valve, T, which is put in motion by hand through the intermedium of a small lever, *l* (Fig. 4). A pipe, *a*, which rises vertically into the vessel, A, leads the water from the latter into the flask, B, after passing through the valve, T. Another pipe, *b*, serves alternately as a conduit for the water coming from A, and for the steam from the boiler. The steam coming from the latter enters through the inlet, C.

As with the apparatus first described, we shall use figures for describing the operation of this one, and these are the ones numbered from 5 to 9.

In the position represented in these figures, the valve has opened the orifice of the pipe, *b*, so that the steam coming from the boiler will rush through this pipe and go to establish, as in the automatic boiler feeder, an equilibrium in the pressure at the upper part of the vessel, B. The water contained in the latter will then flow to the boiler through the back-flow pipe, D, and the pipe, *d*. The water having flowed out, the engineman reverses the slide-valve, T, and thus shuts off the admission of steam. In this new position, the valve, T, puts the vessels, A and B, in communication through the orifices of the pipes, *a* and *b*. The steam contained in B, having still a certain amount of pressure, rushes into the condenso feed-water heater, properly so-called (A), and at once condenses therein, on passing through small apertures formed for such purpose at the upper part of the pipe, *a*.

As we have before stated, the apparatus has been working regularly for more than eight months on a 5-horse power movable engine, where it has given most satisfactory results. Although it has not yet been used on a railway locomotive, we give, in Fig. 8, a theoretical installation of that kind. But, in order to more completely utilize the heat lost by the hot gases that escape up the smoke-stack, Mr. Fromentin has suggested another arrangement in which the feed water heater surrounds the stack. In this case the heater has the form of an inverted funnel, so as to present a greater heating surface to the gases escaping from the tubular smoke-stack. The quantity of heat thus furnished to the water would be more than sufficient to keep it constantly in ebullition. The elevation of water into the hot water well would be effected by means of a small steam-jet elevator placed at the bottom of the tender and actuated by the distribution itself of the feed-water.

Supplying locomotives with very hot water is certainly one of the most interesting of problems, and one which has not hitherto been solved in a truly practical manner; so it is to be desired that Mr. Fromentin shall apply himself as soon as possible to experiments on a large scale.—*Annales Industrielles.*

## BATTERY AND COPPER PLATE AMALGAMATION.

By PROF. R. H. RICHARDS.

VERY little on this subject has been published recently in the mining journals or proceedings of societies. The attention of experts has been diverted, partly perhaps by the demand for pure amalgamation for refractory ores. Yet free-milling gold ores occur in many localities, and it may be interesting to have on record some data as to details of running a small test mill, especially as details of results do not seem to be accessible to students and investigators. Küstel, in 1863, under battery amalgamation, dismisses the subject, by stating that "amalgamation on copper-plated platforms, troughs, and other copper fixings is very imperfect and mostly abandoned." J. Arthur Phillips, in 1867, states under placer mining: "A well-amalgamated copper plate is considered as effective for saving fine gold as an equal surface of pure mercury." In Raymond's reports I find in two volumes mention of amalgamation by copper plate. In 1871, in an admirable article by N. S. Keith, on the preparation of amalgamated copper plates, he states: "The discovery of the utility of amalgamated copper plates in the treatment of auriferous rock in the stamp mill has so simplified and cheapened the metallurgy of gold that it is now profitable to mine, and reduce many gold-bearing ores and rocks that formerly would not pay." In Raymond's report of 1872, J. A. Church discusses the use of copper plates with reference to his theory of amalgamation. I am unable to find any allusion to amalgamation in either Bittinger's or in Goetschmann's excellent works on "Aufbereitungskunde."

Amalgamation was discovered in 1557, by Bartolomé de Medina, in Mexico, and has since that time been introduced in many mining districts. It is the only paying method of extracting fine particles of gold from quartz rock that has yet been discovered, and by it gold ores, which yield no more than two dollars to the ton, are said, in some places, to pay expenses and even a profit.

In amalgamation, as at first applied to gold-quartz ores, the sand was slowly carried over pools or shallow tanks of mercury. The gold particles settled from the sand, and were alloyed and absorbed in the mercury bath beneath. Later, these pools of mercury were used in the form of ripples, that is to say, diminutive pools, as, for example, in the Attwoods amalgamator. In both of these cases the gold was finally obtained, after the mill had been run for a specified time, by filtering the whole of the mercury through chamois skin, and thereby leaving the gold amalgam in a pasty condition on the filter. This amalgam was then heated to redness, and the pure gold obtained.

The last great improvement in treating gold ores has been in the substitution of copper plates coated with a bright surface of mercury, which serves to seize the gold with equal if not superior readiness to that claimed for pure mercury. The method does away with the use of such large quantities of mercury, and also saves much of the loss of that metal.

The various difficulties encountered in amalgamating will be well understood when we recall the experience in the Institute laboratory during the last eight years, which includes the whole period of development of our mill to its present state of perfection.

In the winter of 1872 the little five-stamp battery was started in good earnest; small lots of ore severally from North Carolina, Georgia, Colorado, and New Hampshire were run in the mill and over the plates; after each run the plates were cleaned up and the amalgam retorted. Our tailings were not as clean as we could have hoped, and the yield of gold therefore was not so high as we expected, for causes which will be partialy accounted for later in this paper. After the last of these runs the plate was scraped a second time, and to our dismay some more gold was obtained a third time, and we began to wake up to the fact that we had been crediting North Carolina ore with Georgia gold, and so on. This difficulty became so apparent, and appeared so insurmountable, that we well-nigh despaired of ever using the mill in making careful quantitative tests. I shall speak of this difficulty in this paper as the overlapping error.

Until 1876 we did nothing more with the mill, owing to other cares. During that year, however, we tried a new expedient of overcoming the overlapping error. It was to purchase the thinnest copper that could be found in the market—about one-fiftieth of an inch—and to use a new set of plates with each run, dissolving the old ones in sulphuric acid at the end of the run, and thus to recover the gold. We got back our gold to be sure, but after much trouble; and in this way we entirely overcame the overlapping error. We recovered, after running 1,500 pounds of $14 rock, besides the amalgam which we scraped off, about $2.75 of gold, which had soaked into our plate, ten feet long, six inches wide, or five square feet of surface. Still, the tailings were too rich, and the mill work was not altogether satisfactory. We finally found that, in avoiding the overlapping error by the above expedient, we had run into another and possibly worse error, which I shall call the new plate error.

Men will tell you that no mine is willing to send ore to a mill that has just put in new plates; that the raw copper plate coated with mercury is not well calculated to catch gold; that a layer of gold amalgam must be formed on the surface before the plates can be considered at all reliable.

In fact, we are informed that in the Black Hills and elsewhere a mill with new plates counts it as one of their regular expenses to buy one hundred tons or so of gold ore and run it, to charge the surfaces of the plates with gold amalgam before taking in custom work.

Recently we have adopted the suggestions in N. S. Keith's paper (Raymond's report of 1871); these with certain modifications have overcome all the difficulties, and given us the means to test gold ores by the ton accurately and efficiently.

Our method is to take soft copper plate, one-sixteenth of an inch thick, of the size required, scrub it with sand, sal ammoniac, quicklime, and mercury, until it is plated. Dilute nitrate of mercury will plate the copper far quicker and with less trouble, but not so permanently, so deeply, or so thoroughly. If very obstinate spots are found, dilute nitrate of mecury may be used, and if this fails, a plumber's scraper will remove the spot. When thoroughly plated and washed clean, the plates are dried carefully with cotton batting; mercury is then sprinkled on through chamois skin and distributed with cotton. This will give the plates a brilliant, mirror-like surface, which will remain for several days if water is kept off them. The least addition of water will very soon bring out the yellow stains that are the enemies of the amalgamator. This yellow stain is prevented on old plates by the coating of gold amalgam which has formed on their surfaces.

We have, in the mining laboratory of the Massachusetts Institute of Technology, hit upon an expedient for overcoming the new plate error and the formation of the yellow stain which so much retards the amalgamation of gold. Our device is in the substitution of silver amalgam for gold amalgam. Silver amalgam is made by dissolving silver dollars in nitric acid diluted by equal weight of water, and by then adding about ten times as much quicksilver as silver; the silver is all precipitated, making a pasty amalgam; the liquor, after standing over night, is decanted, and the remaining amalgam washed thoroughly with water; one silver dollar will make amalgam enough to paint four square feet of surface. This amalgam is dried and squeezed in chamois skin to remove the excess of mercury until about the consistency of soft putty; it should then be painted on dry to the bright plates with a flat hog's bristle paste brush. This amalgam should be allowed to drain for at least twelve hours, to avoid as far as possible the presence of free mercury on the plates during the run, as it is liable to flour and be lost.

Silver amalgam is just as good a catcher of gold as the gold amalgam, so far as we yet know. This layer of silver amalgam also overcomes the overlapping error, because the gold never comes to any considerable extent into contact with the copper plate, and hence when the plates are scraped off in the usual way, the silver amalgam practically carries off with it the whole of the gold.

For a testing mill the method is sufficiently easy and simple, and has been adopted by us as overcoming all the difficulties yet encountered.

In order to find out how and where the amalgamation takes place, the gold which settles in the battery, as well as that which settles on each of the five plates, is kept separate; in this way we can easily ascertain whether the gold is coarse or fine, and whether we have too much or not enough amalgamating surface.

Two tests have recently been made, the one on a low grade ore from the dump-heaps of a New Hampshire mine;

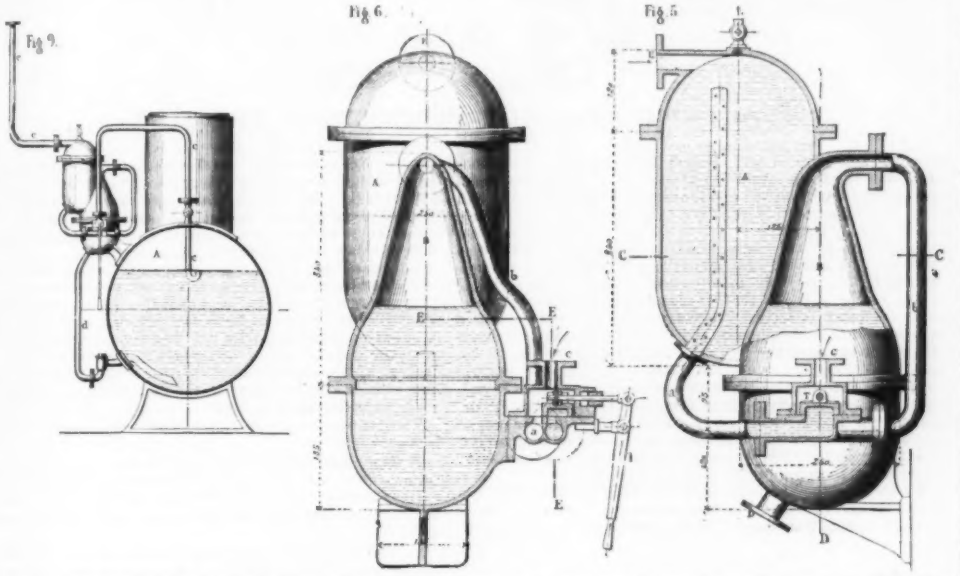


FIG. 9.—APPLICATION OF THE FEED-WATER HEATER TO A STATIONARY BOILER. FIG. 6.—SECTION THROUGH D D. FIG. 5.—SECTION THROUGH E E E.

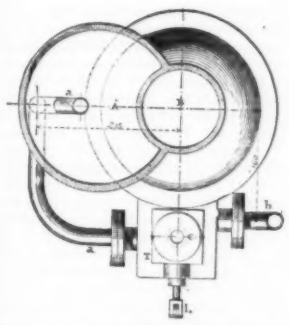


FIG. 7.—SECTION THROUGH C C.

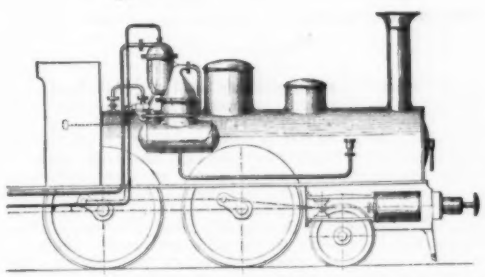


FIG. 8.—APPLICATION OF THE FEED-WATER HEATER TO A LOCOMOTIVE.

## FIGS. 5 TO 9.—FROMENTIN'S CONDENSO FEED-WATER HEATER.

A certain amount of vacuum is then produced in B; and the water contained in A, being driven by that which is coming from the reservoir, E, passes through the pipe, *a*, and follows the same route as the steam. Then the vessel, B, fills up.

In order to feed anew, the engineman has only to reverse the valve in order to give passage to the steam, etc.

The section of the distributing orifices and of the pipes of this apparatus is so calculated that the operations are effected immediately.

The maneuver of the apparatus is, of course, effected according to the requirements of the boiler. Moreover, the flask and the well are calculated so that the engineman has to maneuver the valve only every thirty minutes. The water in the well, A, is generally at a temperature of 90°, and when it passes to the vessel, B, after condensing the steam contained therein, it rises at once by 25°.

Up to this point, we have occupied ourselves with the apparatus as worked by hand only; and we shall now explain how this is effected mechanically.

For this purpose, Mr. Fromentin employs a mechanism analogous to that used in planing machines to cause the advance of the table. The motion is calculated in such a way that the backward and forward travel of the slide-valve may be effected in the time necessary for filling B, and forcing back to the boiler—that is to say, one or two minutes. The mechanism is so constructed that it may be suppressed by the engineman whenever he desires to run the apparatus by hand.

the other from a mine in Nova Scotia. The New Hamphire lot was composed mostly of quartz stained yellow with iron rust, having cavities from which the iron pyrites had been dissolved. It contained a small percentage of pyrites, but no gold that was visible, as we examined the pile. It contained, also, some fine mica schist, which was probably from the wall rock. This lot of ore weighed 2,021·60 kilogrammes, or 4,447·52 pounds. A sample of it yielded to fire assay $4.14 gold to the ton; gold at $20.67 per ounce, troy. The total value, therefore, of the gold in this lot was $9·20. The yields of gold in the different parts of the process, reduced to dollars, were as follows:

| | |
|---|---|
| Battery amalgam | $4·573 |
| First plate | 2·694 |
| Second plate | 0·215 |
| Third plate | 0·180 |
| Fourth plate | 0·099 |
| Fifth plate | 0·050 |
| Mercury trap | 0·038 |
| | $7·849 |

Of the products assays were made, and showed the following results:

| | |
|---|---|
| Original ore, per ton | $4.14 |
| Pulp sample as it went on plate | 2.07 |
| Pulp sample off plates | trace. |
| Coarse tailings | trace. |
| Concentration of pyrites, per ton | 5.17 |
| Fire sluices | trace. |
| Residue in battery, per ton | 17.57 |

This test was made under the superintendence of Mr. W. O. Sargent.

| | |
|---|---|
| Total value extracted | $7.85 |
| Total value by assay | 9.20 |
| Total assay, per ton | 4.14 |
| Total by amalgamation, per ton | 3.53 |

or 85·2 per cent of the gold.

The poverty of the pyrites concentrations found by us corroborates the conclusions arrived at by Prof. Hitchcock, who states that he has universally found the gold in these mines to be in the quartz, and not intimately associated with the pyrites, as it is in some other localities.

The following precautions have been mostly obtained by conversing with mill men from different parts of the country. Our experience entirely confirms the truth and importance of them. The amalgam on the plates should not be allowed to get too hard or too soft. If too hard, it may fail to catch the gold; if too soft, mercury will flour at the lower end of the plate. A quantity varying from one to one and a half ounces of mercury should be fed to the stamps for every ounce of gold contained in the ore under treatment; this mercury should be fed, a little at a time, every half-hour.

If plates are inclined to stain, a lump of cyanide of potassium held over the spot will remove the yellow stain, whereas too much cyanide should be avoided, as it liquefies the amalgam too much. Keith says if an ore contains ferrous sulphate or cupric sulphate (blue or green vitriol) as results of the oxidation of the pyrites, causing stains, a little lime should be fed to decompose this compound, and, hence, to prevent this salt from staining the plates.

The use of oil about the mill should be restricted as much as possible, as this, more than anything else, causes the yellow stain to come. If the cams are oiled with an oily rag on a stick every half-hour, the excess and dripping may be largely prevented. Molasses is sometimes used, but it is a poor lubricant.

It would seem to us that the method adopted in our laboratory is equally well suited for large mills.

The first two cleanings-up would be diluted with silver, as a matter of course, but after this no such trouble would ensue.

For methods of testing these small quantities of gold in tailings, and with any degree of ease and speed, we find the books are barren. The chlorination method gives the greatest encouragement, but this is long and tedious, and has to be tried with the utmost care. The fire assay is of little use, as the quantities used are too small to give any result at all on one-dollar tailings.

We are just now working up an amalgamation method for testing tailings, which gives some degree of promise, and which, if successful, we hope to describe at some future date.

Professor Richards exhibited the above process of amalgamation. Showing the plates with the yellow stains to the audience, he cleaned them off with cyanide of potassium, coated them with silver amalgam, and then, having mixed some gold filings with sand and water, he proceeded to let this flow over the plates, whereupon the plates assumed a roughened appearance, especially near the top, and he then scraped off the amalgam with the gold which it had caught and retained.

He also exhibited several specimens of gold ores, mentioning their characteristics, especially drawing attention to those of fine and those of coarse grains.

In answer to a question by Mr. N. M. Lowe, as to who deserved the credit for the discovery of the use of silver amalgam in this case, he replied that it was one of the discoveries made in the mining laboratory of the Massachusetts Institute of Technology, which is under his charge.—*Proc. Society of Arts, Boston.*

## THE BAUDOT MULTIPLEX PRINTING TELEGRAPH

THE remarkable apparatus invented by Mr. Baudot may be defined as a telegraph which permits of the transmission to a distance, and over a single wire, of the work of four or six employes manipulating at the same moment six distinct keys, and permitting of the reception of four or six dispatches, printed on arrival in ordinary characters on paper bands that may be sealed up and sent to the persons for whom they are designed, as in the Hughes system. The name of "Multiplex Printing Telegraph" is therefore well applied, since it realizes at the same time a multiplex transmission, and prints the telegram immediately on its arrival. When the apparatus is arranged for transmitting the work of four operators at one time it is called *quadruplex*, and when that of six operators, it is styled *sextuplex*. Both these latter forms are founded on the same principle.

In order to obtain an idea of the *modus operandi* of so complex an apparatus as the Baudot telegraph, it is necessary to proceed from a simple to a compound form, and to study the parts as a whole, all practical difficulties being supposed to be suppressed. The theoretical apparatus being once understood, it will be easier to understand the operation of the parts devised for overcoming the difficulties neglected at the outset. We shall, then, in the very first place, describe a much simplified, imaginary apparatus before undertaking a description of the instrument such as actually used.

To get a definite idea, let us suppose two Baudot apparatus to be in communication between Paris and Bordeaux, and the communications to be so arranged that the six operators at Paris are transmitting to Bordeaux.

Let us imagine two vertical axles, one located at Paris and the other at Bordeaux, revolving at identically the same speed, *synchronously*, by a process that will be examined further on; and let us suppose the speed of these axles to be one hundred and fifty revolutions per minute, or two and a half per second, and that each carries a horizontal arm which revolves over a plate divided into six equal sectors. Let us designate each of such sectors by A, B, C, D, E, and F, for Paris, and by A', B', C', D', E', and F', for Bordeaux. The axles revolving with the same velocity, the arms will always be at the same instant upon the corresponding sectors, A and A', B' and B', etc. Suppose that at Paris the sector, A, is in communication with the first manipulator, the sector, B, with the second, etc., and that at the receiving station at Bordeaux the six sectors communicate with six distinct receiving apparatus (Fig. 1); then, if the two axles are connected

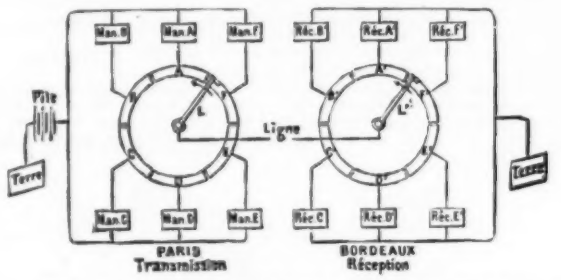



FIG. 1.—THEORETICAL DIAGRAM OF SEXTUPLEX TELEGRAPH.

with the line wire, it will follow that, once per revolution, and for a duration equal to a sixth of a revolution, each manipulator will be in communication with the line and with the corresponding receiver. At a velocity of one hundred and fifty revolutions per minute this duration of communications of the corresponding apparatus will be a fifteenth of a second. If, during this fifteenth of a second, we can by any suitable arrangement transmit the series of conventional symbols that are necessary for the reproduction of a letter on arrival, the corresponding receiver, which is always in communication with the manipulator through the intermedium of the line, will alone receive all such signals and faithfully reproduce them. This is the general principle of multiplex transmission; and it consists in putting the line successively in connection at regular intervals, and for an instant with each manipulator and the corresponding receiver, which registers the signals as they arrive. The intervals between two successive communications serve to prepare the succeeding signal.

Every time the line is put in connection with a given manipulator and the corresponding receiver, the combination of electric signals transmitted, finally terminates in the impression of a letter on the corresponding receiver. Admitting that there is neither stoppage nor interruption in the transmission, the apparatus will print (150×6=) 900 letters per minute, or (900×60=) 54,000 signals per hour for the six apparatus employed. Taking into account the blanks that separate the words, etc., at the rate of six signals per word, and of twenty words per dispatch, the Baudot apparatus, with a velocity of one hundred and fifty revolutions per minute, is capable of transmitting (theoretically) four hundred and fifty dispatches, of twenty words each per hour. With experienced operators, the rotary velocity of the axles may be made to reach one hundred and eighty revolutions, and to thus increase the work performed by one-fifth. Practically, on account of stoppages, interruptions, repetitions, etc., the average is three hundred dispatches of twenty words, transmitted over a single wire, and printed directly in ordinary characters. This is one of the most remarkable results, and of one that Mr. Baudot has, up to the present time, been the first to obtain.

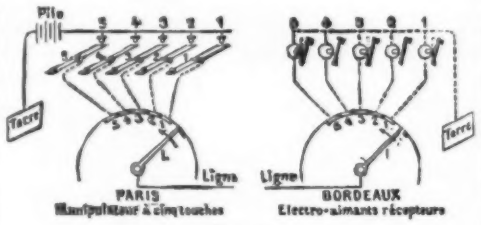



FIG. 2.

We will now turn to a general description of the apparatus. We have seen that, during one entire synchronous revolution of the two axles, the rubbers set up a communication between a manipulator and the corresponding receiver during a sixth of a revolution (Fig. 1). What takes place while the two arms, fixed to the two axles, are synchronously following the sixth of a revolution? To understand this, the sector must be divided into five parts, as we have just now divided the entire circle into six. The five parts of each sector are formed of metallic keys, insulated from each other, and put in connection at the transmitting station with the five keys of a manipulator, and at the receiving station with five distinct electro-magnets (Fig. 2).

The five keys of the manipulator can be raised or depressed in variable number by the operator. The combinations that are possible, by varying the number of keys struck, are thirty-two. One depressed key will send a current into the wire at the moment the rubber is passing over the copper key, and this current will actuate the electro-magnet of the corresponding receiver, which will then attract its armature. When the axles have accomplished the sixth of a revolution the five electro-magnets will have attracted the corresponding armatures (at least for the depressed keys), and these armatures will, through their position, reproduce the very combination of the keys depressed at the outset. A skillful telegrapher, then, might apparently be able, by simply inspecting the positions of the five armatures, to designate the signal sent, and to read the telegram. We must here remark, however, that no such skillful operator exists, for the positions of the armatures change two and a half times per second. Yet, what a human being is powerless to *read* Mr. Baudot allows to be *written* by his apparatus.

A mechanism of marvelous ingenuity, which the inventor calls a *combiner*, and of which we can at present only indicate the action, gathers, so to speak, the combination that the receiving electro-magnets have effected, and finally translates such combinations by printing the corresponding letter upon the paper band of the receiver. This is a result that exceeds all imagination, and that the reader will obtain some idea of it he will follow us to the end of the description that we have undertaken to give.

To sum up, the Baudot comprises five principal, distinct parts, as follows:

1. The *distributer*, which establishes a concordance of communications between the different manipulators and the corresponding receivers, as well as between the keys of the transmitting manipulators and of the receiving electro-magnets.

2. The *five-keyed manipulator*, which allows the different combinations of the current to be sent to the receiving station.

3. The *receiver*, which registers the emissions of current from the corresponding manipulator by acting upon the armatures of electro magnets.

4. The *combiner*, which gathers up the combination received by the electro-receiver, and translates it by printing the letter or other corresponding symbol.

5. The *correcting system*, which acts automatically at every revolution. As the correction takes place at each revolution the errors do not accumulate. The differences of position of the two rubbers are not so great that transmissions shall be troubled thereby, as a consequence of the riding of the sectors on one another. By referring to Fig. 1, and the description of it, it will be seen how the communications pass from one sector to another, and, consequently, from one manipulator and its corresponding receiver to a second manipulator and corresponding receiver. The diagram in Fig. 2 shows the communications of the five contacts of the manipulator for one of the sectors. By following the direction that the currents take it will be understood how the armatures of the electro-magnets reproduce the combinations of the depressed keys of the manipulator at the outset. It will also be understood why it is that the combination made by the operator on the manipulater a *little before* the passage of the rubbers, is transmitted only at the moment when they are passing over the corresponding keys. Practically, there present themselves certain secondary phenomena that oppose themselves to the operation of a theoretical apparatus such as we have just supposed, and we shall now proceed to a study of the actual forms of the apparatus.

In our explanation above given we have supposed, for the purpose of making our remarks clearer, that the armatures of the electro-magnets were influenced by simple emissions of the current corresponding to each key depressed. But, in practice, such is not the case, for there is always an emission of current at each passage of the rubbers over a sector; such emission being *positive* if the key is depressed

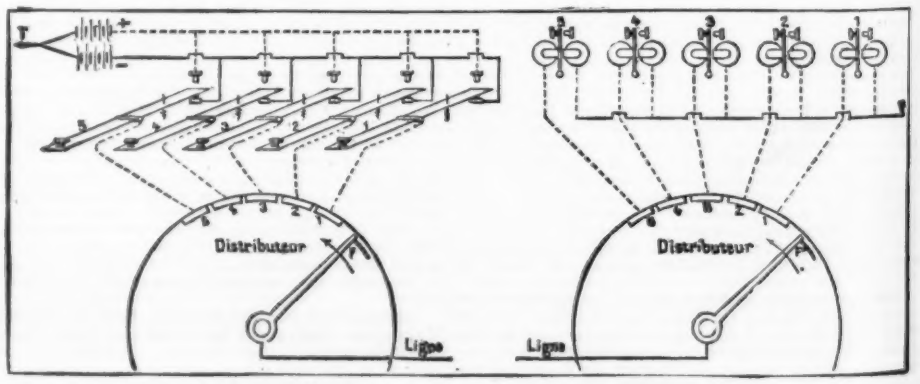



FIG. 3.—MANIPULATOR. RECEIVER.

or in a *working* position, and *negative* if the key is not depressed and is in a position of *rest*.

At the receiving station the electro magnet, instead of being simple, has two branches, between which moves a polarized armature, which takes two distinct positions, according as the current coming from the pole is positive or negative.

The diagram in Fig. 3 shows the combinations which permit of such effects being realized. The *black* (lower) keys of the manipulator correspond to a position of rest, to the emissions of *negative* currents, and to the position upon the *black* contacts of the polarized armatures. The *white* (upper) keys correspond to working positions, to the emissions of *positive* currents, and to the position of the electro receivers upon the *white* contacts. Owing to such a combination, in order to efface a combination of the receiving electros before receiving the one following, it is only necessary to send into each of these electros a negative current which shall put the polarized armatures back into a state of rest. This is what the distributer does, at the desired moment, through the medium of a special rubber which performs the role of an *effacer*.

If, during a complete revolution of the distributers, one of the manipulators is not transmitting, the five keys of the corresponding receiver will rest in the position of repose, and the line will be traversed by five successive negative currents, which will necessarily traverse the five corresponding receiving electros, and will leave the five armatures in their state of rest. If, on the succeeding revolution, keys 1, 3, and 5, for example, are depressed, the five emissions will be successively, +, −, +, −, +; the armatures 1, 3, and 5 will impinge upon the working contacts, while the armatures 2 and 4 will remain in their position of rest. The combination thus effected on the receiving electros will last until it is destroyed by the negative currents from the effacer; and it is in this interim that the combiner will gather it up to transform it into a letter printed upon a band of paper, as we shall see by and by.

Before going further, let us examine the practical forms of the three parts whose operation we have just studied.

The *manipulator*, Fig. 4, consists of a five-keyed key board, analogous to that of a piano. The two keys to the left are manipulated by the middle and fore fingers of the left hand, and the three to the right by the fore, middle, and ring fingers of the right hand. The interval between the two groups of keys is a fixed band, which makes a place for the thumbs on separating the hands slightly. Manipulation then, consists in playing, so to speak, a series of accords by causing the number and order of the depressed keys to vary according to a combination adopted for each letter; this corresponding to thirty-two possible combinations and thirty-one effective ones, since that in which no key is depressed cannot be counted as an effective one. As the bands never change place, it is easy to manipulate very quickly, and, by skilled operators, on lines that are not too long, the distributer may be made to revolve one hundred and eighty times per minute, corresponding to three letters per second and per operator. On the top of the manipulator box there will be remarked a small electro-magnet. This is called the *cadence striker*, and its object is to indicate to the operator, by a small, quick stroke, the instant that he must strike the key or the combination of keys, that is to say, it beats the measure for manipulation. We know that the line is in correspondence with each manipulator and corresponding receiver only during about a fifteenth of a second per revolution. It is during that interval that the five positive or negative emissions must be made. If the keys are not depressed at such a moment the combination is not received, and the operator will have manipulated in vain. The cadence striker clearly indicates the moment at which the combination must be struck, a *little before* the rubber of the first distributer passes over the sector corresponding. A special rubber, controlled by the distributer, passes over the contacts keyed on the sectors of the corresponding manipulator, slightly in advance, and sends a current which actuates each cadence striker just at the proper moment.

The cadence is the same for each operator, since the velocity of the distributer is constant; but the strokes of the different strikers are successive, and take place in measure as the rubber of the distributer approaches each of the sectors that is on the point of being put in connection with the line. A sextuplex apparatus includes six like manipulators at each station.

*The Receiver*.—The receiving electro-magnets, Fig. 5, are arranged in groups of five, each corresponding to one manipulator. They are formed of straight electro-magnets, placed one in the prolongation of the other, and between the extremities of these move the polarized armatures. Six groups of electro-receivers, then, are necessary for the purposes of the six manipulators; but, through an ingenious arrangement, each group of electros is made to do duty twice per revolution, so that a single receiver can do duty for two distinct manipulators, care being taken to group on the same receiver two diametrically opposite manipulators. It is only necessary, then, to have three receivers; the first doing duty for the manipulator, A and D, the second for B, and the third for C and F. In what follows, we shall suppose, for purposes of simplification, that the six manipulators are in connection with six groups of distinct receiving electros.

The polarized armature consists of a small strip of soft iron, whose extremity rests on the extremity of a horse-shoe magnet having three superposed branches and provided with a base containing a notch in which the armature rests. The upper extremity of the strip carries a silver contact which oscillates between two stops, one called the resting stop and corresponding to the emission of negative currents, and the other the working stop, corresponding to the emission of positive. As the armature is polarized it is maintained in the position that has been given it by the passage of the current which has just traversed the electro-magnet—even when the current has ceased to pass—and is displaced only at the moment of the passage of a current in an opposite direction.

*The Distributer*.—We have supposed up to the present that the relations between the sextuplex transmitting station and the receiving station were established by the aid of two axles revolving synchronously at a distance, and connected with the line and each carrying a rubber that passed at the same instant over the corresponding transmitting and receiving section. Practically, the distributer is far from presenting so great a simplicity; and it requires no less than ten rubbers and nine concentric circles over which these ten rubbers may regularly pass in order to set up in the required time the communications necessary to the practical working

FIG. 4.—MANIPULATOR.

of the system. Fig. 6 represents the distributer in its actual form. The two apparatus—one at the sending station and the other at the receiving—are identical, and are set in motion mechanically. At first Mr. Baudot made use of weights as motors, thus demanding on the part of the operator considerable work; but he now employs small turbines on the Humblot system. The motor is located under the table, and transmits motion to the distributer through a small endless belt. The motion is equalized by a fly-wheel, a vibrating plate, and a friction moderator.

The working of the system being intimately connected with the perfect synchronism of the two distributers, it may be readily conceived that the keeping up of such synchronism requires a special apparatus. Such is the case, and we shall describe it.

Let Paris, for example, be the transmitting, and Bordeaux the receiving station. We begin by regulating the velocity of the Paris distributer in a definite manner, say to 150 revolutions per minute, by displacing the counterpoise of the vibrating plate, as in the Hughes system; and we regulate the velocity of the Bordeaux apparatus in such a way that it shall revolve a little faster than the one at Paris. Under such conditions the motion of the apparatus will be kept synchronous within certain practical limits, provided that the Bordeaux distributer be properly retarded every time the change of position in the two distributers is on the point of reaching a limit at which the transmission will no longer be regular and the sectors ride on one another and destroy the concordance that is indispensable. It is the distributer that automatically accomplishes this end. For this purpose, instead of being divided into *six* sectors, as we have supposed above, it is really divided into *seven*, the seventh one occupying an angle of about 40 degrees. The correction is expected while the rubbers are passing over that angle. In reality the Baudot *sextuplex* is a *septuplex*, in which, for one complete revolution of the distributer, the six operators transmit their six combinations, which correspond, during about the six-sevenths, to the six letters. During the other seventh the seventh operator transmits the correction.

The sector devoted to this purpose is styled the *correcting sector*. When the change of position of the arms carrying the brushes exceeds a certain amount, there results an emission of current, which acts upon a relay electro-magnet analogous to the electro-receivers. This magnet closes at Bordeaux the circuit of a local pile upon a principal electro-magnet, which, by a series of ingenious mechanisms, finally produces a change of position of the axles of the rubbers and of the driving axle, and retards the former by 1-225th of a revolution. It should be stated that this change of position in the distributer in no wise changes the movement of the motive system, and that this regulation of 1-225th of a revolution brought about by the correcting system is much below the change of position that the practical working of the system admits of.

If the difference of velocity is very great the change of position will take place at every revolution, and the operator who attends to the synchronism will slightly diminish the velocity of the receiving distributer so that the change shall take place only every five or six revolutions. Under such conditions the correcting system will be effaced, for it will be able to act, if the difference in speed tends to increase, by changing the position every ten or twelve revolutions only; and, on the contrary, every ten or twelve revolutions, if such difference tends to diminish.

It now remains for us, in order to finish the description of the distributer, to point out the necessity of just as great a number of rubbers, although theoretically the system requires but one.

We must first remark that the line is not connected directly with the axle, but with a fixed circle, and that the current from the pile reaching the line through the sectors must pass into this circle through a second rubber moving over it.

For purposes of simplicity we have supposed that the six Paris apparatus were transmitters, and that those of Bordeaux were receivers. Such a condition would divest the system of all practical interest. It is necessary that every conjoined group shall indifferently transmit or receive, according to the exigencies of the service. As a general thing, half the Paris stations are transmitting, while the other is receiving at Bordeaux, and *vice versa;* but this is not peremptory, and the relation of the transmitting and receiving apparatus must be able to vary at every instant without troubling the service. So we find on the manipulator, Fig. 4, a switch which is capable of taking two distinct positions—one of transmission or of reception, as may be required. This necessary reciprocity of the apparatus requires the use of two groups of two distinct rubbers—one of these being reserved for transmission, and being connected with the manipulators, and the other being for reception, and being connected with the receivers.

In order to produce a clear transmission it is important to discharge the line of the last emission of the current, by putting it in connection with the earth for an instant. This is done by two circles and a pair of rubbers.

The distributer is likewise charged with the control of the cadence strikers, which it effects by sending a current from a local pile into each of the rubbers at the proper moment. This also demands one pair of rubbers and two corresponding circles. Finally, the ninth and tenth rubbers serve to set up the communications that are necessary for effacing the combinations of the electro-receivers, and for replacing them against the resting stops.

Owing to this ingenious general arrangement, of which we have now indicated only the principle, every combination effected on one of the sending manipulators is faithfully reproduced in the electro-receivers at the other station. To every key depressed in the manipulator there corresponds, certainly and faithfully, a displacement of an armature in the receiver, and a placing of it against the working stop.

*Explanation of Fig.* 1.—During the synchronous rotation of the rubbers, L L', the manipulators, A, B, C, D, E, F, are in communication with the corresponding receivers, A', B', C', D', E', F', each during one-sixth of a revolution, through the intermedium of the sectors of the two revolving rubbers, and of those of the line. All emissions of current from a manipulator, occurring during the sixth of a revolution which puts it in connection with the line, will, then, reach the corresponding receiver only on condition that the synchronism be perfect.

*Fig.* 2.—While the levers, L and L', are undergoing the sixth of a revolution they set up communications successively with the keys, 1, 2, 3, 4, and 5. As a result of this, if the keys, 1, 3, and 5, for example, of the manipulator, are de-

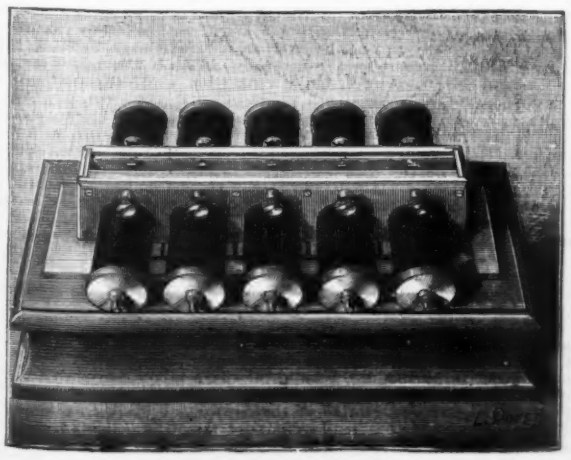


FIG. 5.—RECEIVING RELAY.

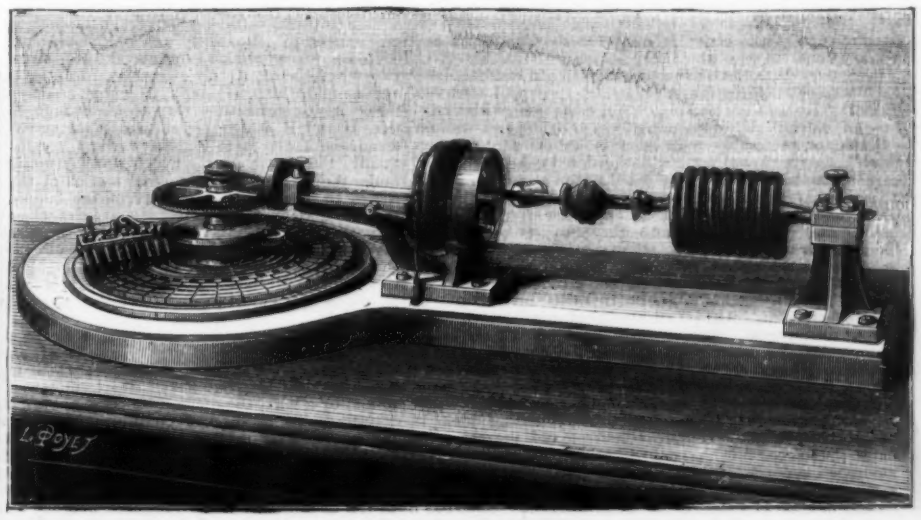


FIG. 6.—DISTRIBUTER.

pressed, while the rubbers, L and L', are passing over the contacts, 1, 2, 3, 4, and 5, there will occur an emission of current from the pile for contacts 1, 3, and 5, and the corresponding armatures, 1, 3, and 5, will be attracted, and take the positions shown by dotted lines.

*Fig.* 3 is a diagram of the electric connections between a 5-keyed manipulator and the electro-magnets of a corresponding receiver. By examining this it will be seen that if none of the keys of the manipulator is depressed there will be five emissions of negative currents, and the five polarized armatures will remain on the resting stops (black), while if a few of the keys, 1, 3, and 5, for example, are depressed, the corresponding receivers, 1, 3, and 5, will be traversed by positive currents, and the armatures will incline from the left to the right, and abut against the working stops (white).

## SECONDARY BATTERIES.

THE important part that secondary batteries will eventually play in electric lighting, renders any items in connection with their construction of great interest. As will have been expected, several patents have been recently taken out, and many others are awaiting publication. Of some of the devices we are enabled to give a brief description, which may be of interest, though there is reason to believe that later forms have superseded them. As we mentioned some time ago, Mr. Sellon has taken out several patents for secondary batteries, and as the development of that invention will form a feature in the electrical history of the nineteenth century, we give a short account of some of his devices supplemented by those of other inventors. In his specification of September 10 last, he describes the use of perforated plates, or sheets roughened, serrated, or indented, composed of lead, platinum, or carbon, upon, in, or against which are held films of spongy or lead salts of lead or other suitable substances. In the drawings accompanying this specification, Mr. Sellon shows lead plates bent so as to form a series of dovetails over the surface, or serrated like the teeth of a saw, both being perforated with numerous holes in which and in the folds of the serrations or the dovetails, the active material can be packed, the object being to get as much as possible of that into the smallest compass. Five days after that specification was deposited, Mr. Sellon appears to have left another, the main feature in which is the use of an alloy of lead with antimony as the material of which the plates are to be composed. It is clear that the ingenuity of the inventor has tolerably wide scope in determining what shall be the actual form of the elements or supporting plates of the secondary battary, and it is obvious that if perforated lead plates are an advantage, they can be made up of a number of short pieces of lead tube, arranged with their axes parallel. We have reason to believe that experience has declared in favor of an alloy of lead and antimony in preference to the simple metal, and for convenience in working or for remedying any accidental effects of local action, plain plates, with many perforations, are preferred to the corrugated and other devices suggested for the purpose of gaining surface. It will be understood that one object of these inventions is to dispense with the canvas or felt supports for the coating of oxide, because in practice it is found that nothing yet tried will long withstand the effect of the acid liquors used to excite the action. Corrugating the plates possesses an advantage in presenting greater surface in an equal space; but when felt or canvas is dispensed with, there is some liability of "lead trees" forming a cross and connecting the two elements of a cell. Hence, it is found advisable to so arrange the plates that any points of contact of that kind can be readily removed. M. de Kabath, of Paris, has also taken out patents for secondary batteries, the feature of his invention being the method adopted to prevent the coating of lead-oxide from falling off. He forms a composite electrode of thin sheets of lead, folded around a thicker sheet which acts as a support, the whole being enveloped in a sheet of parchment-paper, a substance which, having been already acted upon by sulphuric acid, is only slowly destroyed in the battery. In M. de Kabath's design the sheets are either plain or corrugated; but in all cases a thin coat of sulphate of lead is formed upon them, and the form consists of alternate plain and corrugated lead plates, packed between stout lead covers held together by India-rubber bands, the whole being inclosed in a case pierced with holes. M. de Kabath has also taken out a patent for a method of regulating the discharge of secondary batteries (September 20, 1881). That is accomplished by increasing or diminishing the depth of solution in the battery-cell by means of a tap moved by magnets actuated by a relay. Thus when the current in the main circuit decreases, the spring of the relay moves the index and puts into action the magnet controlling the inlet of solution, so that a greater surface of the plates is immersed, and the current is increased in proportion. Similarly, if the current is too great, the tap is so turned as to run out some of the solution from the battery, so leaving a smaller surface of plates under action. MM. Deprez and Carpentier have also obtained a patent (September 24, 1881) for distributing and regulating the transmission of electrical power, in which they use two secondary batteries, so connected by means of a commutator that while one is being charged the other is giving out current; but as they do not specify any form of battery, the claim is only for the details of the arrangement.

Secondary batteries having some really novel features, have been patented by Mr. A. Watt, of Liverpool (October 1, 1881). He uses the lead plates, but coats them with a mixture of calcium hydrate, manganese dioxide, and sodium chloride, or preferably with what is known as "Weldon mud," mixed in equal parts with powdered coke. Plates of carbon may be used instead of lead, and in a solution of sulphate of manganese can be employed in one cell, as the sulphate decomposes and covers the carbon with peroxide of manganese. Another form of battery consists of alternate layers of carbon and granulated manganese dioxide mixed with granulated carbon, preferably in equal volumes, or of lead and manganese dioxide or layers arranged as follows: $MnO_2|Pb|C, Mn_2OC|C, MnO_2|C, PbMnO_2C|C$ and so on, or $Pb, MnO_2C|C, Pb, MnO_2C|C$, the vertical bars representing porous diaphragms. The exciting liquid is salammoniac, common salt, or dilute sulphuric acid. A convenient form of cell consists of an ordinary battery tank divided down the center by a porous diaphragm. The charged porous pots, fresh or exhausted, of Leclanche cells, may even be used without further preparation than immersing them in one of the solutions. If one pot be fresh and the other exhausted, the couple is charged and ready to work. Another modification consists of a porous pot containing a plate of carbon charged with a mixture of manganese dioxide and carbon or coke in a state of coarse powder, and placed in a leaden vessel containing dilute sulphuric acid, the space between the pot and the leaden vessel being filled with a mixture of manganese dioxide and carbon or coke, or simply with granulated lead.

Another secondary battery, which is based on the action of chlorine on copper, has been patented by Mr. A. P. Laurie, of Edinburgh (October 4, 1881). The cell is made up of a thin plate of copper, coated with a paste of cuprous chloride, and wrapped in parchment-paper; that, together with a plate of zinc, is placed in a solution of chloride of zinc, and the two being connected a current is set up, which continues until the cuprous chloride is reduced to a mass of spongy copper. The zinc plate is then withdrawn, and a copper plate put into the cell, which is then ready for charging. The action of the chlorine on the spongy copper can be regulated by means of copper gauze placed over the spongy coat, and connected to the copper plate. These notes, together with those given in page 413, and elsewhere in the last volume, will serve to convey some idea of the different methods of making up secondary batteries. It is tolerably obvious that, but for its weight, lead would be the only metal experimented upon, its advantages being so considerable, especially in the shape of cost; where, however, portability is desired, it is probable that Sutton's or some modification of the copper-lead cell will be utilized. Possibly, the researches of Dr. Gladstone and Mr. Tribe may lead to the discovery of something more valuable than is yet available.—*Eng. Mechanic.*

## ON A NEW FORM OF THE APERIODIC GALVANOMETER.

By MARCEL DEPREZ.

LAST September, I described, in the *Journal Universel d'Electricité*, a rapidly indicating aperiodic galvanometer, which I had devised in connection with Mr. D'Arsonval, and which was specially designed for showing the currents due to very weak electromotive forces, such as those resulting from thermometric actions, or from the passage of a wire of a few centimeters length traversing the magnetic field of a small magnet. I am now going to make known another form of this intrument, which I devised at the beginning of the year 1881 for the purpose of rendering it applicable to cases in which it is desired to measure currents of an extremely feeble intensity traversing a circuit whose external resistance (other than that of the galvanometer itself) is very great. These two forms of the apparatus supply the same wants as ordinary galvanometers, which are of coarse or of fine wire, according to the nature of the applications for which they are designed.

The accompanying Fig. 1 represents this second type of

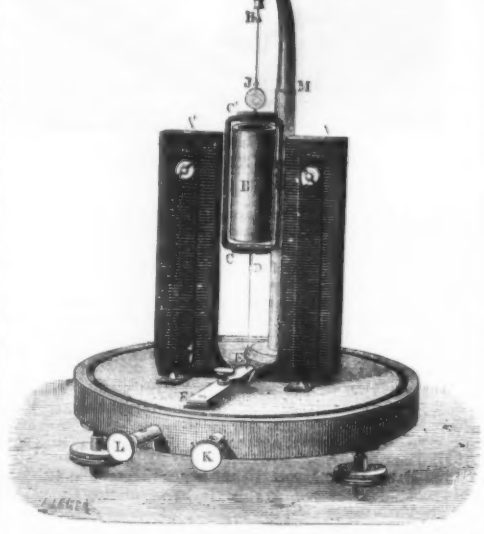



FIG. 1.—IMPROVED APERIODIC GALVANOMETER.

galvanometer. $AA^1$ is a horseshoe magnet whose branches are held in a vertical position by fixing the back into the base of the apparatus. Between the branches there is a rectangular helix, $CC^1$, which is formed of a very fine wire wound a great number of times. This helix is connected with two silver or hard copper wires, JH and DE. The wire, JH, is attached at H to the extremity of a rod which may, at the will of the experimenter, be given two distinct motions—one of rotation in order to set the helix in position, and the other a vertical one in order to place the helix at a proper height. The second wire is attached at E to an elastic strip, EF, whose tension is regulated by the screw, G. These two wires, being tightly stretched, form in space a fixed axis around which the helix, $CC^1$, may assume a rotary motion. At the same time they serve, through their extremities, H and E, which communicate respectively with the terminals, K and L, to lead the current into the helix; and finally, the elastic couple which results from their torsion under the influence of an angular motion of the helix, $CC^1$, serves to measure the intensity of the couple due to the reciprocal actions of the magnet and helix when the latter is traversed by a current. A small mirror, J, permits of reading the angles of torsion with great accuracy by applying the optical process which is employed in all apparatus of this nature. In the interior of the helix there is an iron tube, B, which is designed to strengthen the intensity of the magnetic field.

When the helix is moved by hand from its natural position of equilibrium, it returns to the latter, and performs, while doing so, a series of oscillations which may last for a considerable time; but if the two terminals, K and L, be united by a wire, the oscillations cease at once and the helix returns to its position of equilibrium exactly as if it were moving in a fluid of great density. This phenomenon is due to the retarding mechanical action of the induction currents developed in the helix by its motion in the magnetic field. This a very valuable feature when the instrument is applied to the measurements of resistances, and one which permits of performing them within an incomparably shorter time than can be done with the apparatus universally employed. I am anxious to state, moreover, that such a feature is in no wise obtained at the expense of sensitiveness, for the latter does not cede at all to that of the most perfect instruments employed up to the present time. In order to give some idea of this, it will be sufficient for me to say that it clearly indicates a current whose intensity is one ten-millionth of an ampère.

A description of this galvanometer naturally leads me to speak of the graduation of such instruments in general, and I shall point out the process that I now employ, and which appears to me to be superior to all those that have hitherto been published. It is an application of the Poggendorff method of measuring electromotive forces.

Suppose G, Fig. 2, to be a galvanometer to be graduated; P a constant current pile; and $p$, a pile whose electromotive force is taken as a type. The current of the pile, P, being closed by the wire, PBAP, and that of the type pile, $p$, by the circuit, $pAGBgp$, these two circuits are put in contact by the points, A and B. The result is that the three portions, AGB, AB, and $ApgB$, are traversed by three currents whose intensities may be easily calculated when the resistances of these three portions are known, as well as that of the portion, BPA, in which is located the pile, P, and when

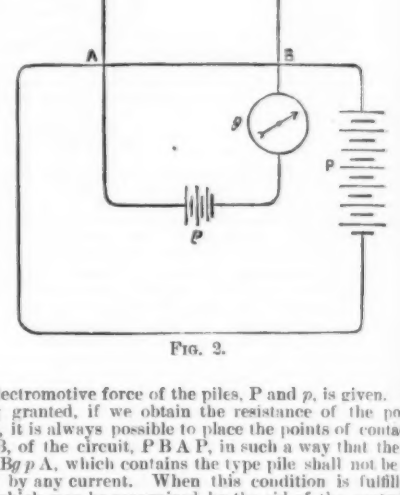



FIG. 2.

the electromotive force of the piles, P and $p$, is given. This being granted, if we obtain the resistance of the portion AGB, it is always possible to place the points of contact, A and B, of the circuit, P B A P, in such a way that the portion, $Bgp$ A, which contains the type pile shall not be traversed by any current. When this condition is fulfilled (a fact which may be recognized by the aid of the central galvanometer, $g$), the difference of potential of the points, A and B, is exactly equal, and of a direction contrary to the electromotive force of the type pile, $p$. The portion, AGB, whose resistance is given, is then traversed by a current whose intensity is at once given by the formula $I=\frac{ne}{r}$, in which $e$ represents the electromotive force of one element of the type pile, $p$; $n$, the number of elements of such pile; and $r$, the constant resistance, AGB. It is easy, then, by causing $n$ to vary (which naturally carries with it a variation in the distance of the points of contact, A and B, of the two circuits in order that the current circulating in the portion, $Bgp$ A, be always brought back to zero), to carry the graduation as far as may be desired. If we take as a unit the current traversing AGB, when $n=1$, we may obtain intensities represented by any fraction, $k$, whatever of such unit, on adding to the known resistance, A G B, an auxiliary resistance equal to $\left(\frac{1}{k}-1\right)r$.

It will be seen that this absolutely accurate method permits of graduating instruments whose wires have any resistance whatever, either in volts or in ampères, without there being any need of knowing anything else than the resistance of such instruments (which can be determined with extreme precision) and the electromotive force of the type pile. This latter, moreover, operates always with open circuit, this, as well known, being an indispensable condition in order that the electromotive force may be considered as invariable. It is scarcely necessary to remark that the auxiliary pile, P, should be composed of a number of elements dependent upon the limit to which the graduation is desired to be pushed.

## MICROSCOPES AND MICROSCOPY.

By DR. ROYSTON-PIGOTT, M.A., F.R.S.

THE following is the substance of a lecture recently delivered by Dr Royston-Pigott, F.R.S., to the Eastbourne Young Men's Christian Association. The subject was Microscopes and Microscopy, and some remarks on light formed the introduction. Why, said the lecturer, should its hottest rays be absolutely dark? Why should electric light kill vegetation in some cases unless it first passes through glass? Why should a bar-magnet which lifted six pounds be able to lift nearly double the weight by two days' exposure to an Italian sun? The solar rays are always pouring magnetism into the earth. The sun attracts the earth with as much force as though the whole of its surface were pulled to the sun with the strength of steel rods, thick as the blades of grass. Again, why should magnetism be poured out from the sun principally by the violet rays? Magnetic storms also exhibited on the earth correspond to changes on the solar disk. Again, why should electricity be always present with magnetism as truly as a shadow follows the light? Let us examine what light is by its known phenomena. It is resolvable and may be recomposed. It is radiant and can be turned from its course.

*Deviation by Refraction.*—On this principle the action of the microscope entirely depends. This very principle of deviation, however difficult for man to deal with, is the means of displaying the beauties of the rainbow, the glories of the heavenly hosts, the dazzling flashes of oriental gems, the gorgeous coloring of the dewdrops sparkling in the rising sun, the flashing loveliness of the hovering moth, the splendors of the golden west, and the awful sublimities of the Arctic aurora—itself a magnificent phenomenon. The inconceivable powers of sight conferred on a minute insect,

every one of whose thousand eyes is a hundredfold more powerful in magnification than the strongest human microscope, result from the same property—*deviation*. Again, water-sight is wonderful—a fish sees a horizontal bank elevated on high with great precision by the reflection of light passing through water. And on the same principle the modern microscope, by means of a drop of water covering the object, is immensely improved by what are now called immersion lenses, which crowd a much greater number of rays from the object along the line of sight. The microscope entirely depends on the qualities of a prism for decomposing light and bending the rays toward its thicker side. The pictures on the wall give us all these details. A lens is really a series of minute prisms. It enables the observer to see an object like an insect settled upon it. But by using compound lenses in exact imitation of the formation of the human eye, the colors at first developed by refraction are reunited into white light. An enveloped image is again remagnified by another set of lenses and thus the total magnification may amount to several thousand times. Armed with this great microscopic eye, the naturalist plunges into a new world of structural wonders. The chemist studies the dissolution and recombination of the elements; the geologist recognizes the minute remains of organisms myriads of ages old, chiefly used by nature to build up mountains, continents, and islands. The physician detects sure signs of organic disorder and even minute living organisms pervading the very blood of man. The expert reproduces the old blood stains of the murdered or the entombed poison used by the assassin—the adulteration of food and the distinctive marks and signs of different bodies—and distinguishes the paste from the diamond at a glance. Impossible is it to enumerate the innumerable uses of this noble instrument. In magnifying power it far exceeds the telescope—and unlike it, can be applied at all times and seasons. It is essentially a home instrument, and it delights hundreds of thousands of its votaries with an interest ever new and inexhaustible. It was the microscope that first demonstrated the circulation of the blood—a discovery stubbornly scouted by the whole of the doctors of the day. It revealed the nations on a leaf and the swarms of animal life in a speck, whose minuteness is so great as to baffle human conception. Malpighi first saw what Harvey had sagaciously asserted—the streams of blood globules traversing a frog's foot. Sea mosses and sea ferns were found to be forms of animal life. The ancient fable of the Hydra was revived and reinstated. Corallines now were seen to be animals. To the microscope we owe the disproval of spontaneous generation. The various parasites which infest the bodies of animals, causing infinite trouble, and those which attack cultivated plants as blight or fungi, the spread of disease germs, the movements of minute cells in the sap of vegetables, the various and beautiful forms of minute eggs—each true to its own type; these, and a thousand other things, show how vastly our knowledge and power of research has been extended by the microscope, by presenting us with a deeper insight into the mysteries of life. Not only every human tissue has been explored, but I might say those of the whole animal kingdom. "What," says a well-known writer, "can be a more worthy occupation than the attempt to gain an insight, however limited, into the operations of creative wisdom?" These are as wonderful in the smallest as in the largest animal. No insignificant part of the globe's crust is made up of myriads of microscopic skeletons, principally formed of flint, equally indestructible by fire and aquafortis. No instrument more promotes the faculty of philosophic reasonings. Microscopic pursuits at once engage our highest faculties, whether merely as an absorbing recreation or as a profound research embodying a system of ascertained facts of high value. The microscope brings man face to face with nature in her most minute details. A whole evening may be delightfully spent over the head of a single spider. The eye is not satisfied with seeing, and this instrument more than any other at once both gratifies and stimulates the thirst for knowledge and advancement in the works of nature. "A walk without an object," says Mr. Kingsley, "is a poor exercise, unless in the most lovely and novel scenery, and as a recreation is utterly *nil*. If we wish rural walks to do our children any good we must give them a love for rural sights, an object in every walk. We must teach them—and we can teach them—to find wonder in every insect, sublimity in every hedgerow, the records of past worlds in every pebble, and boundless fertility in the barren shore; and so by teaching them to make full use of that limited sphere in which they now are, make them faithful in a few things, that they may be fit hereafter to be rulers over much."

To teach by rote, by book and board, is too often to disgust the tender wonder of budding youth, while real nature presented excites a most lively and abiding interest. A school-boy's holiday consists in the liberty of the fields like the flight of a caged bird. Human curiosity and delight is inexhaustible among the microscopic riches of infinite forms and functions. To quench this spirit of inquiry by birch and lesson is one of the saddest outcomes of a bygone pedagogism. Some strong spirits, it is true, survive long years of literary slavery to the desk and slate; but alas, in too many cases, this system has driven its nauseated victims into the full enjoyment of coarser pursuits. If the microscope engages youthful curiosity, elevates the taste, raises the mind from a love of sordid to ennobling pursuits, it must be a great boon to rising manhood. Innumerable microscopic societies have thus sprung up all over the world, and their doings fill thousands of "Transactions." But I must have done with these eulogies, though I might add such societies unite in singing the charms of nature's minutest works. I cannot better illustrate the action of the microscope than pointing to the oxygen lamp illustrating the subject. If you suppose a microscope forty feet long, furnished with an object glass of a few inches focus, the object is so magnified by distance of the screen as to require no eye-glass for further amplification. These glasses before the lamp are constructed with the highest art. As no simple glass can form a distinct image at a distance by its own refraction, on account of the unequal deviation of the various colored rays, means are taken to unite as many as to produce white light, leaving, however, generally a little outstanding color at the margin. If only white light could be used containing no violet or other colored rays this margin would disappear; then, however, the difficulty of bringing all the rays to one precise focus for every point of the picture—a difficulty described by the term aberration—is so great as to tax the highest skill of either mathematician or artist. Photographic lenses are simply the same in which the picture is taken in the reverse course from the object, and a very perfect miniature formed on collodion. Some of the most interesting sights the microscope can display is metamorphosis. The larva of the straw-colored plumed gnat (*Tipula crystallina* of De Geers), emerges from the egg in May and June (it inhabits almost invisibly the water). It rapidly changes into the pupa about three quarters of an inch long and a tenth thick. Keeping it in clear spring water retards the change. Its transformation commences under the eye of the observer—a most interesting spectacle. So complete is the change that its former organization can no longer be recognized in its new state of existence. The tail had consisted of 22 beautiful plumes. It converts itself into two fine membranes permeated with numerous vessels. Not the slightest resemblance remains, nor are any vestiges of tail to be seen in the water. Two small horns appear folded up in the head destined to form the white plumed antennæ. The food canal appears nearly to vanish in the pupa as it takes no food in that state. During the latter part of the day the rudiments of perfect legs may be traced. It now floats in a vertical position, the head being only just submerged. It had formerly swum in a horizontal position. The circuitous mode of these transformations is truly wonderful. The mere bursting forth of the perfect creature from its envelope is but a small part of the complicated transformations it has gradually undergone. The circulation of the blood in these insects is quite visible, though it is transparent by the onward movement of little oat-shaped blood corpuscles in vessels furnished with closing valves as perfectly constructed as those of the human veins. The breathing apparatus of insects shown by the microscope evidences beautiful design. As they have no lungs or gills, air is conveyed through trachea or tubes around which a network of blood vessels are employed to aerate the blood by diffused circulation. The dorsal vessel pulsates, the oat cells are seen to pass rapidly forward. The action of the valves is a most beautiful sight. The air vessels pass down each side of the body along the legs, the horns, or antennæ and the three-forked tail, while the blood corpuscles circulate to each (the larva of the day fly). I cannot resist relating an observation on young tadpoles. I observed one of these lively captives did not produce his legs, while his fellows were leaping out of the basin. The microscope showed he was suffering from a real poverty of the blood—few particles only could be seen like solitary sentinels slowly pacing along their routes. Nutrition had nearly ceased. But the study of formation gives marvelous insights into design—means devised for special ends. An India-rubber tube is guarded and strengthened with spiral wire. The breathing tubes of insects are wound round and round with elastic fiber in two different directions, producing a very beautiful wavy appearance. Again, the human eye lens is exceedingly complex, though in health transparent. It has a curvature different on each face so as to produce the most distinct image on the retina, which is a receiver of the images formed there. A black ball is visible about two miles off if about ten inches in diameter and elevated on a pole against a dull sky. Now, what do you suppose is about the size of this black ball as pictured on the retina? It is readily shown by optics that its size is about the one hundred and twenty thousandth part of an inch, and yet the optical vision of a really good eye is equal to a result which severely tasks the powers of a very fine microscope. I have frequently seen a black object of this kind. What must be the microscopic arrangement of the tissues of the eye to enable it to convey the impression of such a minute black dot as this to the brain? But much smaller points than this are distinguished if brilliant. The eye is, in fact a microscope in itself, but used to form miniatures, photographs, as some think. The eyes of insects, however, apparently greatly exceed ours in complexity and contrivance. They have no eye-lids; they must see all around at once to escape their enemies. Accordingly we find great variety in the quantity of actual eyes studding the head; 4,000 in the house fly, 17,000 in the common cabbage or yellow butterfly, 24,000 in the dragon fly, 25,000 in the mordella bettle. Each eye is made up of two lenses and an intervening cylinder, and tapering pyramids prolong the whole to the nerve fibers. The light is regulated in each by a layer of black matter (pigment) perforated by a minute aperture (just as we are obliged to use in the microscope or telephone to shut off extraneous light). What complicated design and execution, arrangement, order, precision, and baffling minuteness are here in the head of the smallest insect!

## ON THE CARE OF THE INSANE.

A GOOD deal of interest has been manifested in the investigation going on for some time past by a special legislative committee, consisting of Senators Woodin, Fowler, and Pitts, relative to the management and condition of the insane institutions throughout the State. These gentlemen have just completed an interesting report to the Legislature, in which they make the following statements:

On the 30th of March, 1879, a petition was presented to the Legislature in which charges of maladministration were made against the various lunatic asylums of the State and against the State Commissioner in Lunacy. The matter was referred to the Committee on Public Health. That committee made its report on the 22d day of May in that year. The investigation made by that committee, and their report based thereon, were made the subject of comment and criticism by the New York Neurological Society—a society numbering among its members some of the most eminent men in the medical profession in the city of New York, who, in January, 1880, published an answer, in which it was claimed that the report of said committee was unjust, *ex parte*, and untruthful, and said charges were therein reiterated. The action of this society was widely circulated, the effect being to create a general feeling of distrust in the public mind as to the management of the lunatic asylums of the State, and a demand for the further investigation was pressed upon the attention of the Legislature, and in pursuance of said demand this committee was appointed.

The committee have visited most of the lunatic asylums of the State, and have examined as witnesses superintendents of asylums, attendants, trustees, managers, medical experts not connected with asylums, patients confined therein, the State Commissioner in Lunacy, and whoever they thought might be able to throw light on the matters under investigation. As their labors progressed new and additional subjects of inquiry unfolded themselves, so that the committee have not limited their examination to the specific charges made, but have attempted to go over the whole field of lunacy administration.

In regard to the general and special problems of insanity, the following propositions are sustained by the latest and best research:

### INSANITY INCREASING.

*First.*—Insanity is a physical disease, a disease of the nervous system, and is obedient to the same laws of causation, of progress and treatment, as other diseases of the nervous system. It is no longer regarded as something outside of or apart from human nature, but it is understood everywhere among students of the nervous system that insanity is to be studied, not by or of itself alone, but as part of a large and increasing family of nervous diseases to which it belongs.

*Second.*—Insanity, though it has existed for ages, and is found rarely among savages and barbarians, is yet, taking all its varieties and phases and its present frequency, preeminently the disease of modern civilization. It is most frequent among those people who are most highly civilized, who live within doors, and are subjected to the greatest mental strain and anxiety. Insanity is least frequent among savages, somewhat more frequent among partially civilized but dull and sluggish people, more frequent still among those of slowly progressing civilization, and most frequent of all and most rapidly increasing among those people who, in all the lines of mental activity, are now leading the civilization of the world.

*Third.*—The increase of insanity is out of proportion to the increase of population in all highly civilized countries.

In Great Britain, where much pains are taken to secure accurate statistics of insanity in public and private asylums, it has been estimated by one of the presidents of the British Psychological Association, that if insanity were to increase in England and Wales as it has increased the last forty years, there would be in the year 1912, 1 250,000 of insane persons. It was estimated that in 1850 that there was in Great Britain about one lunatic to every 1,000 persons. According to the very elaborate report of the Lunacy Commissioners of Great Britain in 1880, there was one lunatic in every 357 persons; in England and Wales the year before, one lunatic in every 360 persons, thus showing an increase out of proportion to the population, not only at long intervals but even from year to year. The statistics of Massachusetts also show an increase of lunacy out of proportion to the population. It is quite safe to estimate that in our own State there are in and out of asylums not far from 13,000 lunatics in a population of 5,000,000, or about one to every 384 of our population, the proportion not differing essentially from that shown by the statistics of England and Scotland.

### PAUPER INSANE.

*Fourth.*—The increase of insanity has been most rapid among the poor, although there has been a marked increase among the higher classes, both the intellectual and wealthy. This increase of insanity in the pauper classes is now, and for a long time has been, out of proportion to the increase of pauper population. It is not peculiar to our own State or country. In England during the last thirty-three years the increase of insanity among the pauper class has been 300 per cent., while the population has increased only at a rate of 45 per cent., and the very latest report of the English Commissioners in Lunacy shows yet more explicitly that the increase of insanity among the pauper class is largely out of proportion to the increase of the pauper class itself. Of the more than 70,000 lunatics in England, all but about 12 per cent. are paupers.

An incidental fact connected with this subject, and one of startling force, is that in our State very many families, reduced almost to pauperism by their efforts to support insane relatives in public or private institutions where high prices were exacted and paid, have been compelled by lack of means to go to public asylums, and have gradually reduced their expenses and comforts until not only they, but their friends who supported them, are thrown upon the State. It has been estimated by the reports of the State Board of Charities, that the increase of expenditure by the Government for charities is far out of proportion to the increase of population, and by all who are conversant with this subject it is admitted that the care of the pauper insane and those who are pauperized by insanity, is a large and rapidly increasing item in our governmental expenditure for charities.

### SMALL HOPE OF CURE.

*Fifth.*—Insanity is becoming more and more incurable. This results largely from the operation of the inevitable law of inheritance. Insanity, like other nervous diseases of the family to which it belongs, is becoming organized in families, and just as with other nervous diseases, the more powerful and long continued the hereditary taint or influence, the less hopeful are the chances of permanent recovery. It has been recently demonstrated by Dr. Pliny Earle, of Northampton, Mass., and more recently by Dr. Tuke, of England, that the statistics of the recovery of the insane in all asylums are very fallacious indeed. Patients who relapse very many times are reported as cured over and over again every time they are discharged from an institution. Some persons have been discharged as cured twenty or thirty times. The chance of permanent and perfect cure of the insane is very small, certainly not more than one or two out of every ten are really cured. It is believed that there is little or no prospect that the treatment of the majority of cases of insanity of the severer forms in any asylum will ever be much more successful than it is now. The chief success of the future will be in preventing insanity by hygiene and by warding off the early premonitory symptoms. In this direction there is room for progress. The chief grounds on which a revision in our treatment of the insane is demanded are humanity in treatment and economy in expenditure. Our present system of managing the insane in this country and in this State is to be criticised, both on the grounds of want of humanity and of economy.

### PARTIALLY AND MILDLY INSANE.

*Sixth.*—The number of mildly, moderately insane is increasing in our modern civilization. There is a larger proportion than formerly of lunatics who are comparatively harmless, who may be treated and managed successfully at home under the charge of students of the nervous system or the family physician, either with or without the aid of nurses. This outer circle (so to speak) of persons who are not positively insane, but partially so, or at least liable to become so, but are neither dangerous to themselves nor to society, is certainly widening in all our centers of civilization. Through the operation of the law of inheritance most of these persons became parents of those who will be hopelessly insane, and in process of time will be thrown upon the State. The highest authorities on this department of the nervous system agree that new phases of insanity have arisen in the present century—new symptoms and new types, of which our fathers knew nothing—that this increase has gone on side by side with the development of various nervous diseases that are allied to insanity and sometimes lead to it.

*Seventh.*—There has been during the last half century an increase in functional nervous disorders that do not belong to insanity proper, but yet are allied to it. This general increase of nerve sensitiveness is most noticeable in this country, but it is very marked also in England and on the continent of Europe. If this feature was peculiarly and

wholly American it would most likely be attributed to habits to which we as a people are addicted, whether they relate to business or pleasure, eating or drinking, sleep or rest, or, what is nearer the truth, the lack of habits, of sleep or rest. But, however we may speculate as to its causation, we have the fact before us, and it is one of fearful import, since we may safely assume that in the next generation these nerveless, or nervously exhausted people will become the parents of those who are predisposed to insanity, if not actual lunatics.

### CARE OF THE INSANE IN OTHER COUNTRIES.

*Eighth.*—In our systematic treatment of the insane in asylums, public and private, and in our supervision of asylums we are in this State very far behind Great Britain. While there is no country in the world where physicians are more intelligent than here, yet there is no great country that is so far behind in organizing and systematizing the progress that has been made by individuals in appropriate legislation, while our physicians are unsurpassed if not unequaled in scientific attainments and practical skill and in hygienic knowledge in the treatment of nervous diseases, including insanity. We are behind Europe in not having a central supervisory lunacy commission. In England this commission has existed between thirty and forty years, and it has in that time wrought many changes and instituted many valuable reforms in spite of superintendents and officers of asylums who at first were jealous of any interference. The powers of the commissioners are necessarily comprehensive, but they are wielded gently yet firmly, and very successfully. The commission is a guarantee against profligate expenditure. The commissioners are consulted in regard to all constructions, alterations, and improvements in asylum buildings, and in regard to the apportionment of offices. Their reports each year give elaborate details in regard to each institution which they are required to visit. They examine the records and registers of asylums, give heed to the letters of patients addressed to them, see that if possible no patients are improperly admitted to asylums or improperly retained in them. Patients, whether kept in public or private asylums, are regularly visited by them.

The system of central governmental supervision in Scotland seems to be even better than that of England, in that it is more simple if not more thorough. The first great need of our State is the appointment of a Lunacy Commission, consisting of three or more persons specially fitted for such an important trust, and when such a commission is appointed and vested with adequate authority by appropriate legislation, every needed reform will gradually be developed, while under the present system, or rather lack of system, they may in the future, as in the past, be retarded to the detriment of taxpayers.

The expense of caring for the insane is annually increasing. The State has contributed money enough had it been judiciously expended in construction to have furnished a well appointed asylum for each lunatic in the State, as well as for the estimated increase in the next twenty years. The fault is one that cannot now be remedied, but the future of our State in providing for the cure and treatment of the insane ought to be wholly exempt from the follies of the past. Among those who have given attention to the subject there is entire unanimity that the asylums of the future should be more simple in construction, located upon economical farms, where patients may be employed with profit to the State and immeasurable advantage to themselves—less to gratify the æsthetic taste of asylum officials, and more for the comfort and recovery of the insane.

In Europe this reform is already begun. The chronic and incurably insane should as far as possible be kept apart from the acute insane. The increase of insanity has been to a great degree among the chronic insane. Patients of that class do not need the expensive accommodations and appliances of a curative hospital. It is well known that if the insane who are sent to asylums do not recover during the first year of treatment there is little ground for hope of recovery. They pass into the class of chronic insane. Such institutions, for instance, as the Island Hospital, of New York city, have no excuse for their existence. The chronic insane in those institutions could be and should be kept economically, and far more comfortably upon a farm or farms, more or less remote from the city, where they could in part at least support themselves by their labor.

Too little heed is given to the value of labor as a therapeutic agent in our asylums generally. In the best asylums of Europe labor is the rule—non-labor the exception. Of 541 pauper patients in the Royal Edinburgh Asylum 28 women and 18 men only were prevented by their condition from being profitably employed. In the West Home of the Royal Edinburgh Asylum there were 347 private and pauper male patients. Of these 254 were profitably employed—184 in outdoor work. Employment is not only profitable but healthful. In the Willard Asylum every patient, male and female, in a condition to labor is systematically employed in some way; if not always profitable, in a pecuniary sense, yet never without great advantage to the patients. On these points the best authorities are everywhere agreed—viz., that labor is an invaluable aid in doing away with mechanical restraint and also with the use of narcotic remedies. If for no other object than the substantial abolition of mechanical and chemical restraint of the insane humanity demands that our asylum authorities make employment of patients one of the most prominent and distinguishing features in their administration.

### A HUMANE METHOD DEMANDED.

The medical officers in many of our asylums and the attendants also under their influence show a disposition to resist the introduction of changes and improvements in asylum management which observation and experience in other countries have demonstrated to be invaluable in the treatment of the insane. We do not doubt that our superintendents as a class are men of ability, conscience, and humanity, but the pertinacity with which the most of them resist the introduction of methods which distinguish the asylums of England, Scotland, and Germany above all others is not easily accounted for.

The humane advance of Pinel in removing chains and other cruel instruments of restraint from the insane was made in spite of earnest protest of conscientious men. So at a later day, when Connolly ventured a step further and favored a practical, absolute non-restraint, English alienists resisted vigorously the methods of that great reformer and predicted the most disastrous results and a record in the management of the insane over which humanity would blush. But Connolly's courage was equal to his convictions, and non-restraint became the rule in English asylums, and his humane example has not ceased to have its influence in other countries. In Scotland every appearance of restraint is being removed—doors are unlocked, windows are not disfigured by massive iron bars, and almost absolute freedom is given to inmates.

### VALUE OF STATE SUPERVISION.

We do not, of course, recommend any legislation which shall determine methods of care and treatment, but it is our confident belief that central State supervision will aid much in getting the officers and attendants out of the rut which long-continued service and habit have formed, and, what is of prime importance, will tend to allay the rapidly growing distrust among the people by affording just assurance that those who are so unfortunate as to lose their reason are treated economically, scientifically, and humanely. It has been stated by competent persons, and is believed, that at least $2,000,000 could have been saved to the State in the last twenty years had there been intelligent and economical State supervision over building of asylums, and that without any sacrifice of the comfort of the patients. The committee think it is unwise to authorize the establishment of small local asylums for the care of the insane, as in almost every case it must happen that what the taxpayer saves in expense is more than lost to the patient in a lower standard of care.

The commission—the creation of which we recommend—should be given ample powers to look after the interests of the State in the matter of expenditure and to protect the patient in the matter of physical care, with full powers to redress all grievances and remedy whatever wrong they may discover.

## GENERAL HINTS TO THE DISPENSER.*

As quickness and dispatch are generally considerations in pharmacy, it is advisable to keep some of the more frequently prescribed salts in solution; and a few hints as to the most convenient strengths of these solutions may not be out of place here. Bicarbonate of potash, 1 oz. (troy), dissolved in enough distilled water to measure 4 oz., makes a very suitable stock solution, as ½ oz. of it contains 1 drachm or 60 grs. of the salt. Chlorate of potash, 1 in 24, made in the same way, is the best strength to suit all variations of temperature. The salt is soluble in a smaller quantity of water, but is apt to crystallize with changes of temperature. Epsom salt, 1 in 2; bromide of potassium, 1 in 3; and chloral hydrate, 1 in 1, make very convenient solutions, the latter particularly so, as each minim represents 1 grain of chloral, and it is stable and easily calculated.

Some of the official pill masses become very hard on keeping, and get so brittle as to be unmanageable; they may, with great advantage, be kept in the dry state, the powdered ingredients being mixed together, so that the menstruum ordered by the pharmacopœia to give consistence may be added at the time of dispensing. In this way, pil. colocy. co., pil. aloes barb., and socot., pil. aloes et ferri, and pil. Plummeri may be kept with the required proportions of the requisite menstruum marked on the bottles in which they are contained. This plan is often a great help if the physician happens to order too soft a mass.

Mistura ferri co. can also be kept in a concentrated form, so that every drachm will contain the constituents of an ounce of the mixture, except the sulphate of iron, which is to be weighed out and added the last thing before dispensing. Mist. cretæ can be easily kept in powder, ready for the addition of cinnamon water.

The use of concentrated infusions and decoctions, so often employed by pharmacists, is to be condemned. These preparations should be always made fresh as required. It cannot be too strongly impressed upon the student's mind that substitution should never be practiced.

Often the dispenser will be at a loss to understand the meaning of the prescriber, when he orders some preparations out of their official names, and he then must have a consultation, or fall back upon the experience of himself or others. A few examples may be given: When magnes. calc. is ordered, magnesia should be used; when magnes. carb., the heavy preparation is usually intended; when bismuth or bismuth alb. is prescribed, the subnitrate is the preparation generally in the mind of the physician; when aqua menth. is ordered, aq. menth. pip. should not be used, but aq. menth. sativ. is the intention of the prescriber. [?]

Liq. morphiæ is very often written in a prescription, and the dispenser will do well to always employ liq. morph. mur. B. P. (¼ grain in 1 fl. oz.). When extract. aloes is written, the rule should be to use the socotrine.

Much confusion unfortunately exists in the memory of some prescribers about the mercurial chlorides, and fatal consequences have resulted. The subchloride is often written hyd. chlor., hyd. mur., hyd. submur., and the perchloride is occasionally prescribed as hyd. chlor. or hyd. bichlor.

If the dispenser find it impossible to consult the physician in such cases, he will not regret giving the subchloride, if more than one-fourth grain is ordered in each dose.

When the physician orders salts, like pot. iod., or roots, like gentian, with directions for their solution of infusion by the patient himself, the dispenser should destroy their identity by the pestle before sending them out. Quinine for the same reason, if ordered in a mixture without a solvent, should be carefully triturated till the crystals are broken up.

When the pharmacist gets a prescription where incompatible substances are ordered, it is clearly his duty to compound it, unless absolutely incompatible, in which case the different ingredients will not mix, and then, if possible, he should consult the prescriber. Instances of such might be given to fill a large volume, and unfortunately no rule can be laid down for the guidance of the young dispenser, as it is still an open question with pharmaceutical authorities whether a compounder is justified in altering a prescription, suppose he find the emulsifier or pill excipient ordered by a medical man unsuitable. Much will depend upon his knowledge of, and his relation to the prescriber; but where a consultation is impracticable, the dispenser must rely upon his past experience.

Perhaps the greatest difficulty will be met with in the case of pills. A commonly ordered pill is one containing 2½ grs. of sulphate of iron, and 2½ grs. carbonate of potash. Any liquid added to this would promote decomposition, and experience proves that a little vaseline and cacao butter make an excellent excipient. Iodide of protassium is often ordered in pills, and may be made up by rubbing the salt with a few drops of water into a stiff, smooth paste, and working it into a good mass by the addition of a little licorice powder; in this way, six grains may be easily got into a fair-sized pill. The proportions of water and licorice are not given, as they entirely depend upon the samples of iodide, which vary considerably in their suitability for making pill masses.

Phosphorus is occasionally ordered to be made into a pill, *secundum artem*, that is, in whatever way the dispenser thinks best. It should be dissolved in bisulphide of carbon, and while solution is being effected, two or three drops of chloroform may be added, which produce a heavy vapor around the solution, and prevent the oxidation of the phosphorus by the atmospheric oxygen. A little licorice powder may now be added, and the mass quickly made into a workable form with tragacanth paste, divided into pills and coated.

Carbolic acid (Calvert's pure cystalline) may be easily made into pills with wheaten flour, in the proportions of 1½ grs. flour to 2 grs. of acid.

Permanganate of potash can be made into pills with cacao butter.

Camphor, after being powdered with a few drops of spirit, makes a nice mass with tragacanth paste. Three grains of powdered acetate of potash may be made into a suitable pill with Canada balsam, and will remain stable.

Powdered pill or extract of colocynth may be easily worked into a mass with a few drops of decoction of aloes.

Croton chloral should not be treated with the tragacanth paste, which dissolves it, and causes the pills so made to flatten. It is best worked up with a little confection of hips and thick mucilage.

Sulphide of calcium, now much ordered for acne, should be mixed with an equal quantity of sugar of milk, and after careful trituration, as much powdered decorticated licorice root added as will make the weight up to may a grain or more. The mass can now be easily worked up with a little tragacanth paste. Sugar of milk makes the best powder to aid the subdivision of an active substance, and the powdered decorticated root of licorice is the best inert powder for making up pill masses, as it is so fine and impalpable that it does not make a crumbly pill like powdered gentian.

Citrate of iron and quinine make a good pill with the tragacanth paste, but it will not remain hard as the salt is deliquescent.

Copaiba can be made into firm pills, which keep their shape, by adding a very small quantity of carbonate of magnesia to it. Powdered rhubarb makes a good mass with one-fifth its weight of glycerin. Gallic acid, 5 grs., and glycerin, ½ drop, make a good pill. Four parts of quinine and one of tartaric acid, with q. s. of tragacanth paste, make a very excellent mass.

Chlorate of potash and hypophosphite of lime rubbed together explode, and may cause injury to the dispenser.

Creosote, if ordered with oxide of silver in a pill, will explode unless the oxide be first diluted by trituration with some inert powder, like licorice or gentian, before adding the creosote.

Borax, powdered and rubbed up with mucilage, forms a soft powder like moist sugar, which cannot be made liquid by the addition of any further quantity of mucilage; and acetate of lead, similarly treated, makes an opaque white jelly.

Spirit of niter will generally require to be neutralized with bicarbonate of potash before being compounded with bromide or iodide of potassium, otherwise free bromine or iodine will be liberated, and the mixture darkened.

Subnitrate of bismuth is often ordered in a mixture with bicarbonate of soda, and unless very great care is taken in compounding them, by permitting decomposition at a gentle heat, carbon dioxide will be produced, and the bottle will burst. This may be prevented by using an equivalent quantity of the subcarbonate of bismuth.

Pessaries and suppositories containing green extracts may be readily made by first rubbing the extract with powdered castile soap to about one-fifth part of the bulk of the whole pessary or suppository, and supplying the remainder of the basis with cacao, when the mass can be worked up like a pill in a mortar, and shaped by the fingers, or thrust into moulds previously dusted with powdered starch.

Chloral hydrate can be made into a suppository by digesting it on a water-bath in cacao butter, in which it is soluble.

In conclusion, it may be mentioned that, when a prescription is repeatedly compounded, the patient often asks for the dose to be increased, or some other change to be made, and the dispenser is warned not to accede to such a request, no matter how simple it may appear, without a consultation with the prescriber; nor is it advisable for him to inform the patient (even when pressed) of the ingredients in any prescription. He can refer them to the physician, or do as the writer has done long ago when it was impossible to avoid such a revelation—read it in full Latin to the patient. It need hardly be mentioned that, in the case of repetitions of medicines of all kinds, they should invariably be dispensed in fresh bottles or vessels, and have new labels attached in every instance, though old ones may seem scarcely soiled. Breach of this law is certain to soon get the dispenser into disrepute.

* From Dr. Whitla's "Elements of Pharmacy, Materia Medica, and Therapeutics." [We have not altered the author's nomenclature.—ED. N. R.]—*New Remedies.*

## ON SMELL.

By WILLIAM RAMSAY, University College, Bristol.

THE sense of smell is caused by the contact of certain substances with the terminal organs of the olfactory nerves, which are spread as a network over a mucous membrane lining the upper part of the nasal cavity. Each nerve consists of a number of small bundles, themselves capable of being split into extremely fine nerve fibers. There are spindle-shaped cells connected with these nerves, from which proceed two processes—one to the surface, provided with bundles of long hairlets; the other passes to the interior. It is these hairlets which are probably the proximate cause of smell.

Let us consider, first, by what are smells excited? The operation of smelling is performed by sniffing, that is, by a series of short inhalations of air, bearing with it the odorous body. The first question which suggests itself is: Is the substance which excites sensation a liquid, solid, or gas? It has been tried by Weber, to fill the nose with eau-de-cologne and water, lying on the back for that purpose, and pouring the liquid into the nostrils by a funnel. No sensation is produced. I have myself tried the experiment, and can confirm his observation. There is an irritating feeling, but no smell. Of course, on washing out the nose, or blowing it, the characteristic smell is at once noticeable.

It is easy to prove that solid particles are not the cause of smell. If the air conveying the odor be filtered through a tube filled with cotton wool, and inserted into the nose, a smell is still descernible, although all solid particles must

thereby be kept back. But it is a very remarkable circumstance that it is so, for one would not suspect such extremely non-volatile substances as copper, iron, silver, etc., to give off gas, if indeed the smell which they most certainly evolve when rubbed is due to the gas of the substance.

We must, therefore, conclude that the sense of smell is excited by gases only. It is, of course, necessary to include under the name gases the vapors of liquids or solids which have low vapor-tension, and which, in consequence, give off vapor at the ordinary temperature. It has been proved that this is the case even with mercury, the boiling point of which is over 300° Centigrade. We may consequently conclude that many other substances of which it is impossible to measure the vapor-tension at ordinary temperatures, owing to its extreme minuteness, also evolve gas, if only in very small quantities. But it is well known that all gases have not the power of exciting a sense of smell. Let us compare some gases which have smell with some which have none, and endeavor to discover if those which have smell have any other property in common.

The following is a list of gases which have no smell: Hydrogen, oxygen, nitrogen, water-gas, marsh-gas, olefiant-gas, carbon monoxide, hydrochloric acid, formic acid vapor, nitrous oxide, and ammonia. Those which possess smell are chlorine, bromine, iodine; the compounds of the first two with oxygen and water, the second three oxides of nitrogen (or perhaps it is right to say nitric peroxide, for the other lower oxides are changed into it when they come into contact with air); the vapors of phosphorus and sulphur; arsenic and antimony; sulphurous acid, carbonic acid, and almost all the volatile compounds of carbon, save those already mentioned; some compounds of selenium and tellurium; the compounds of chlorine, bromine, and iodine, with the above named elements; and some metals.

In considering this list, I submit first, that the property of smell is peculiar to some elements and their compounds. Thus, chlorine, bromine, iodine, sulphur, selenium, and tellurium, which are volatile or give off vapor at ordinary temperatures, have a characteristic smell. We should expect their compounds to have a smell, and we find this to be the case. Second, those substances which have no smell, or produce simple irritation of the nostrils, have all low molecular weight. Such is the case with hydrogen, the element of lowest specific gravity. Such also is the case with oxygen and nitrogen; but this as well as the absence of smell in water-vapor, may be ascribed to the constant presence of these gases in our atmosphere, and their necessary constant presence in our nostrils, so that we may be insensible to their smells because we are always inhaling them; but I think it probable that this is not so. Hydrochloric, hydrobromic, and hydriodic acids, and ammonia, have purely an irritating effect, and cannot be described as smells. When ammonia is pure and free from compounds containing carbon, it has no trace of smell. Nitrous oxide is also the lowest of the oxides of nitrogen, and as such has the lowest specific gravity. But it is when we turn to compounds of carbon that we are best able to draw general conclusions; for that element, *par excellence*, has the faculty of forming almost innumerable compounds, and series which resemble each other in properties, but differ in specific gravity. And here we are most struck with the fact that increase of molecular weight, *i. e.*, increase of specific gravity in the form of gas, produces, to a certain point, smell. Let us examine the simplest series, viz., the marsh-gas or methane series, commonly called the paraffins. The first two of these have no smell. Ethane, indeed, which is fifteen times as heavy as hydrogen, begins to have a faint trace, but it is not till we arrive at butane, which is thirty times heavier than hydrogen, that a distinct sensation of smell is noticed. In the same manner, the olefine series, of which the first member is ethene, or olefiant gas, gains in smell with rise of molecular weight. Of course, the highest members of this series have no smell, for they are non-volatile, but this is the case with most carbon compounds of which the molecular weight is high.

A similar relation is noticeable among the alcohols. Methyl alcohol, in a state of purity, is smelless; ethyl, or ordinary alcohol, when freed from ethers and as much as possible from water, has a faint smell, and the odor rapidly becomes marked as we rise in series, till the limit of volatility is reached, and we arrive at solids with such a low vapor tension that they give off no appreciable amount of vapor at the ordinary temperature. Again, with the acids, formic acid is smelless, and produces a pure sensation of irritation. Acetic acid has a slight but characteristic smell; and the higher acids of the series, propionic, butyric, valerianic acid, etc., gain in odor with increase in density in the form of gas. If we consider the nitrogenous compounds of carbon, we are led to the same conclusion. Prussic acid is not smelt by more than four persons out of every five; but the nitriles, which bear the same relation to prussic acid as the higher members of a series bear to the lower, have all very characteristic odors. Acetylene would appear to form an exception to this rule; but carefully purified acetylene has little odor, and it is surpassed by its higher homologues. We may, therefore, I think, accept this as a principle—that the intensity of the smell rises with rise in molecular weight.

It is also noticeable that the *character* of a smell is a property of the element or group which enters into the body producing the smell, and tends to make it generic. Thus we can characterize the compounds of chlorine and its oxides as chlorous; indeed we may group the three elements—chlorine, bromine, and iodine together, and name the characteristic odor of them and their oxides haloid smells. Similarly, sulphur, selenium, and tellurium, in their compounds with hydrogen, have a generic smell; and likewise arsenic and antimony. The only oxide of nitrogen which is smelt is nitric peroxide, so that it is impossible to pronounce on a generic smell for this substance. It is, again, easier to classify carbon compounds. The smell of the paraffins is generic; so is that of the alcohols, the acids, the nitriles, the amines with their irritation like that of ammonia, the bases of the pyridine series, the hydrocarbons of the benzene group, the higher hydrocarbons, such as naphthalene, anthracene, and phenanthrene. Give any one of these to a chemist familiar with the smell of any one of each series, and accustomed to use his sense of smell, and he will at once refer the body to its class.

The tendency of a rise in the series is to make the smell "heavier," less ethereal, and more characteristic. It also becomes more able to affect the olfactory nerves.

The rate at which smell travels is doubtless the rate at which the vapor which gives rise to it diffuses. Still it is impossible to test this experimentally. For the ease with which a smell is perceived varies with the molecular weight of the substance. Thus, if a piece of cotton wool be impregnated with ethyl alcohol, and placed in one end of a long tube, which is immediately corked, and a similar arrangement be adopted with amyl-alcohol, the fifth of the series of which the former is the second; although their specific gravities have the ratio of 23 to 44, and the ethyl-alcohol should diffuse 1⅞ times as rapidly as amyl-alcohol, yet the smell of the latter will be perceived first, because a much smaller quantity produces the sensation.

It is possible, with practice, to make a fairly accurate analysis by means of the sense of smell. The method is, knowing the constituents of a mixture, to prepare one which has the same smell, measuring the proportions of the ingredients. The only precaution to be observed is that the smell of no member of the mixture be so overpowering as to mask those of the others. Thus I have analyzed, or rather synthesized, a mixture of chloroform with ether, alcohol with ether, and these liquids with carbon disulphide, provided the latter be pure, to within 2 per cent.; but I failed with members of the pyridine series. Yet it was possible to detect the proportions of members of that series to each other; and it is not difficult, however extraordinary it may appear, to guess approximately the boiling-point of a mixture of members of a series, after some practice, purely by its smell.

So far as I know, no theory has been brought forward to account for the sense of smell; and I therefore venture to supply this want, premising that what follows is merely a tentative explanation, and as such will, I hope, not be too severely criticised.

There is a probability that our sense of smell is excited by vibrations of a lower period than those which give rise to the sense of light or heat. These vibrations are conveyed by gaseous molecules to the surface network of nerves in the nasal cavity. The difference of smells is caused by the rate and by the nature of such vibrations, just as difference in tone of musical sounds depends on the rate and on the nature of the vibration, the nature being influenced by the number and pitch of the harmonies.

Let us see what evidence can be adduced for the theory. Among the lightest substances which have smell are sulphureted hydrogen and phosphureted hydrogen, both of which are seventeen times as heavy as hydrogen itself. Prussic acid is fifteen times as heavy as hydrogen and has a smell. But all persons are not able to perceive it. I have remarked an average of one in every five persons who are totally unable to detect its odor. Here we reach the lowest limit of molecular weight. *To produce the sensation of smell, then, a substance must have a molecular weight at least fifteen times that of hydrogen.* If we compare the hydrocarbons of the paraffin series with each other, and similarly the olefine series, we notice that the lower members have no smell. The specific gravity of marsh-gas, $CH_4$, is 8; that of ethane, $C_2H_6$, 15; propane, $C_3H_8$, is twenty-two times as heavy as hydrogen, and here we first notice smell. Olefiant gas, $C_2H_4$, has the specific gravity 14, and has no smell; propane, $C_3H_6$, has a faint smell with a specific gravity of 21; and the higher members of the series increase in intensity of smell with increase in specific gravity. Hydrocyanic acid is smelt by most persons, but not by all. Its specific gravity is 15. The higher members of the series, called the nitriles, have all very characteristic smell. Formic acid vapor has the specific gravity 23, and has a purely pungent odor. Acetic acid, 30 times as heavy as hydrogen, has a faint smell when pure; opionic, butyric, and valerianic acids have strong smells. Methyl alcohol has no smell; its specific gravity is 16; ethyl alcohol, 23 times heavier than hydrogen, has a faint smell; and, as usual, the intensity, and if I may so term it, the flavor of the smell, increases as we rise in series. These are the most typical instances of the carbon compounds, and they suffice, I think, to show the justice of the assertion that the intensity of smell increases with rise of molecular weight. The hyphothesis of vibration satisfactorily explains this. The period of vibration of the lighter molecules is too rapid to affect our sense; there is a limit to this power; and just as some people have the power of hearing more acute sounds than others, so some senses are limited by a specific gravity of 15, and cannot smell prussic acid. Such people also have difficulty in perceiving the odors of bodies of slightly higher molecular weight than prussic acid.

Let us now inquire what is the probable rate of such vibrations. Mr. Johnston Stoney and Prof. Emerson Reynolds have made investigations of the ratio of the bright lines of some spectra, and have calculated their relations to each other. An analogy will make the nature of this relation more evident. When a note, say C below the treble clef, is sounded on a piano, not only the tone C is heard, but its octave C on the third space; also G above the line, C on the third ledger line, E on the fourth, G on the sixth, B flat above the G, and other notes. These are called harmonics, or over-tones. Now, if we knew these over tones, it would be possible to refer them to their fundamental. So with light. The light evolved by incandescent gases consists of certain colors, which have each their own rate of vibration. Knowing these rates it is possible to calculate the rate of vibration of the fundamental. This has been done by Mr. Stoney (Royal Irish Academy, January 9, 1871) with hydrogen, with the following results:

| | | |
|---|---|---|
| Wave-lengths, | $\lambda$, 4102·37 | tenth-seconds. |
| " | F, 4862·11 | " |
| " | C, 6563·93 | " |

There are the 32d, 27th, and 20th harmonics of a fundamental whose wave-length is 0·1313 millimeter. The time of vibration is 4·4 fourteenth seconds. It may be objected that these coincidences are not a proof. But Mr. Stoney and Prof. Reynolds have measured the lines of the spectrum of chromyl chloride, and its 31 lines coincide with those calculated. The probability of the correctness of such a calculation approaches to almost absolute certainty. Now we have no means of recognizing such fundamental vibrations, unless, indeed, the sense of smell is one means of receiving them. And it is this which appears to me probable; so probable, indeed, as to form a working theory.

But it is to radiant heat, I think, that we must look for indications of harmonics of the fundamental vibrations which are, according to this theory, the cause of smell. And a fresh proof may be drawn from the indications already seen. Prof. Tyndall has shown the power which odors have of absorbing heat-rays. There is no doubt that by refracting such heat-rays by means of a rock-salt prism, after they have passed through an atmosphere of odor certain portions of the heat spectrum show colder spaces, each corresponding to the particular rate of vibration which is absorbed by the vapor, through which the heat-rays have passed. By measuring the position of such gaps in the heat-spectrum, calculating the particular rate of vibration of the rays at such gaps, and referring them to their fundamental, we should arrive at the rate of vibration of the molecule which causes smell.

We may now inquire what it is which produces quality of smell. This, I think, can also be explained by the vibration theory, and depends on the harmonics of the vibration. Thus, the quality of tone of a violin differs from that of a flute by the different harmonics or overtones peculiar to each instrument. I would ascribe to harmonics the quality of smell possessed by different substances. And it is to this that compounds of chlorine, phosphorus, etc., owe their peculiarity of odor. The odor of compounds resembles that of these elements to some extent; this may be accounted for by the similarity of overtones of compounds and their elements. Then we notice a similarity in the quality of the odor of a compound of a series like the alcohols, and yet the quality grows flatter and heavier with increase of molecular weight.

Smell, then, may resemble sound in having its quality influenced by harmonics. And just as a piccolo has the same quality as a flute, although some of its harmonics are so high as to be beyond the range of the ear, so smells owe their quality to harmonics, which, if occurring alone, would be beyond the sense. It must be remembered that the harmonics are not heard separately from the fundamental, unless special means be adopted to render them audible, but they add their vibrations to those of the fundamental.

When two sounds are heard simultaneously, they give a concord, or a discord, but each may be separately distinguished by the ear. Two colors, on the other hand, produce a single impression on the eye, and it is doubtful whether we can analyze them. But smell resembles sound and not light in this particular. For in a mixture of smells, it is possible, by practice, to distinguish each ingredient, and as I have shown, to match the sensation by a mixture.

With regard to the mechanism by which smell is conveyed to the nerve, all that can be said is pure speculation. But as it is supposed that the vibrations of sound are conveyed to the auditory nerve through the small cirrhi, or hairs which spring out of round cylindrical nerve-cells in the superficial layer of connective tissue of the epithelium of the internal ear, and that each is attuned to some particular note of vibrations, so it may be imagined that the hair-like processes connected with the spindle-shaped cells, themselves communicating with the nerve-fibers of the olfactory nerve, are the recipients of the vibrations causing smell. Although the rate of such vibrations is extremely rapid, no less indeed in the case of hydrogen than 4,400,000,000,000,000, or the four quadrillion four hundred trillionth part of a second, yet the wave-length is by no means so small, for it averages the 2-100th of an inch, a magnitude quite visible with the naked eye. And hydrogen has no smell; those bodies which have smell, and higher molecular weight, must necessarily have a slower period of vibration, and possibly greater wave-length.

It is doubtful whether there exists a lower limit to our sense of smell. The vapors of osmic acid, carbon tetrabromide, selenium, tellurium, and arsenious and antimonious oxides are among the heaviest known, and they have a most distinct smell. There appears to be a limit in practice, however, owing to the non-volatility of substances of high molecular weight at such temperatures at which smell may be perceived. The intense perfume of flowers is to be ascribed to the terpenes, of which common turpentine is one, or to their products of oxidation, and these bodies all possess a molecular weight of 136, and the specific gravity 68, a specific gravity which appears to excite the olfactory nerve most powerfully.

I bring forward the theory adduced with great diffidence. The problem is to be solved, in my opinion, by a careful measurement of the "lines" in the spectrum of heat-rays, and the calculation of the fundamentals, which this theory supposes to be the cause of smell. Such measurements and calculations, even if they proved the theory untenable, would have great value for their own sake, and labor expended in this direction would not be lost. Whether successful or not, it would at least be a first assault on what old John Bunyan called "Nose-gate of the City of Mansoul."—*Nature.*

## OUR DRINKING WATER.

By N. B. SIZER, M.D.

CHEMICALLY pure water is generally to be found only in the laboratory, as the chemist is the only one who absolutely requires it; but rain water, falling through a clean atmosphere, is very nearly pure, containing, however, substances washed out of the air, as oxygen and carbonic acid, traces of nitrates, ammonia, HS, and sulphuric and sulphurous acids, besides dust and particles of various origin, not, however, of a nature or in a quantity great enough to be usually deleterious to health.

Other kinds of water, as spring, rain, pond, lake, and sea water, all contain varying proportions of these impurities, frequently sufficient to be harmful.

Oxygen may be considered as only *chemically* an impurity, being not only harmless to *man* but also the "breathing material" for fish, without which they could not live.

Carbonic acid is inert, as regards ingestion, and gives the brisk, sparkling appearance to spring water and to the falsely so-called "soda-water." Although it is innocuous *per se*, its presence in potable water is always to be regretted, since its presence in a stream flowing over a limestone country enables the water to dissolve a large amount of salines otherwise comparatively insoluble.

It is found by experiment that *pure* water is able to dissolve only 7 or 8 grains of carbonates per gallon, but that the presence of $CO_2$ enables the same amount of water to hold in solution over 250 grains of these salts.

"Hard" water is pure water containing certain dissolved salines, *not* useful as food to a healthy man, injurious to the health if persisted in, and, so far as we know, useful, medicinally, only when the health is deranged.

Certain it is that no *sane* man would think of adding "Epsom," "Glauber" or "Rochelle" salts to his tea or coffee to "improve its flavor," and yet this is practically what all do who use "hard" water, these *hard* waters being merely weak solutions of various sulphates and carbonates. Pure water exposed to a clean mountain air in a desert country, away from human contamination, lying in a granitic or other insoluble basin, makes the most grateful of beverages, carbonic acid, if it be present, adding a peculiar freshness to its taste.

There can be no doubt that health *does* "demand pure water," and that a water not appreciably "pure," in a *chemical* sense, is unfit *hygienically* for use.

This is easily understood when we estimate the amount of these impurities taken per day. The Thames water, containing, say, 20 to 25 grains per gallon of carbonates and sulphates, would compel each adult using two quarts daily to swallow 10 to 12 grains of salines, whose average medicinal dose may be stated at 4 to 5 grains, thus getting a fair dose three times a day. Many wells contain 50 to 60 grains per gallon of alkaline carbonates, and it would be easy to com-

pute in the same way the dose a thirsty soul would take during our sultry August days.

As a matter of course, persons accustomed to pure water are apt to suffer from diarrhea or some enteric difficulty on being compelled to use these saline waters; but as in the case of tobacco, opium, whisky, or any other poison, use breeds tolerance.

If we consider for a moment the function subserved in our economy by the water we drink, we shall see very forcibly why hard water does us harm. Leaving out of the account the water lost by transpiration through the lungs and skin, we may state, in a general way, that the use of water is to *wash* the *blood clean*—that is, to dissolve and carry out of the blood the waste materials picked up by the blood, which are *soluble* in water. Now, we all know that a liquid can only dissolve a *certain proportion* of any solid; therefore, if we partly destroy the solvent properties of our potable water by *previously* putting into it from 10 to 50 grains per gallon of various salines, it is easy to see that we destroy its power of dissolving and removing from the blood anything like the proper amount of waste material, and that if it be thus overloaded with dissolved salines, the water will be very apt, like an exhausted laborer, to *drop part of its load* the first chance it gets.

These deposits occur in very important and delicate organs—notably the kidney, ureter, and bladder, forming the prove dangerous, from suddenly cracking and allowing the water to come into contact with red-hot metal, resulting in a rapid evolution of steam, or sometimes in an explosion. In many parts of the country this fact compels steam users to employ apparatus specially constructed to purify the water prior to using it in the boiler.

All trades using much soap are also sensibly inconvenienced by calcareous water, as not only must about twice the usual amount of soap be used, but a considerable quantity of soda in addition, to soften the water. The cost of *hard* water to London, in excess of what *soft* water would cost, is well shown as follows:

London uses about 1,000 tons of soap per month—that is, 12,000 tons per annum—worth, roughly, about $250 a ton; that is $3,000,000 per annum paid for soap only. Now, half of this soap is wasted, for it would not be used if the water was soft—say $1,500,000 wasted on soap every year!

It is estimated that 250 tons of bicarbonate of soda are used per month in London for softening the water; this, at $60 per ton, is $15,000 per month, and $180,000 per year; adding cost of soap and soda, we have *one million six hundred and eighty thousand dollars* wasted per year, only as payment for the folly of using hard water. Let us now compare a few figures showing analyses of different waters. London (bad river water), Rhine, at Bale (good river water). Hard well (Trafalgar Square, London):

GOOD CITY WATER.

(GLASGOW, LOCH KATRINE, CROTON, N. Y., AND RIDGEWOOD, BROOKLYN.)

| Minerals. | Thames. | Rhine. | Hard Well. | Glasgow. | New York. | Brooklyn. |
|---|---|---|---|---|---|---|
| Lime | 83·8 | 55·5 | 18·8 | 1·9 | Average three months, 1868. Inorganic matter. 96 | Average three months, 1868. Inorganic matter. 64.4 |
| Magnesia | 4·7 | 4·8 | 9·1 | 0·8 | | |
| Soda | 9·2 | 0·6 | 265·3 | —— | | |
| Potash | 4·2 | —— | 99·0 | —— | | |
| Carbonic acid | 119·9 | 86·2 | 197·0 | 1·7 | | |
| Sulphuric acid | 31·4 | 15·4 | 180·5 | 5·6 | | |
| Nitric acid | —— | —— | —— | Vegetable only. | | |
| Organic matter | 49·7 | 3·3 | 13·0 | 11·4 | 28·1 | 11·8 |

The figures are parts per million by weight

diseases so common in limewater districts—"*gravel*" and "*stone in the bladder*," or "*urinary calculus*."

Another but almost as important point is the effect produced by the alkaline nature of most hard water.

The reaction of the urine *in health* is *acid*, and, in many diseases, *alkaline*—the alkalinity being also easily produced by taking alkaline medicines, "hard" water also producing this effect.

Accordingly we find that, in seasons when the London water is particularly hard, many physicians find it necessary to put patients suffering from digestive, intestinal, and renal diseases upon *distilled water* as a drink, exclusively, and with the happiest effects.

Reverting to the subject of calculous diseases, we shall find that a geological map of Great Britain shows beds of chalk and allied carbonates extending along the eastern coast, running as far north as Scotland. This fact explains why we read in Holmes' "System of Surgery" (perhaps the best text-book on the subject in the world), the remark that "calculous disorders are extremely prevalent along the eastern coast of this country, and are found as far north as Scotland"—that is, wherever the soil is full of carbonates of soda and lime, the water will dissolve it, become "hard," and produce calculi in the inhabitants. There is reason to believe that other diseases are influenced by the use of calcareous water, as seen in the "Cretins" in Switzerland, and the prevalence of goiter in Derbyshire, a county notorious for water contaminated by earthy salts.

In the "Report of the London Board of Health on the Water Supply," 1850, it is remarked that, "since the supply of soft water to this city, urinary and dyspeptic complaints are less frequent, continued fevers *more seldom and less severe*." (This includes typhoid, typhus, and relapsing fevers, of course.)

Dr. Paton, of Paisley, Scotland, has noticed that since the introduction of soft water into that town (which formerly depended upon calcareous wells), calculous disorders are very rare, while formerly they were very numerous. He has also noticed that in the two cholera epidemics those families using well-water were far more severely afflicted than those supplied with the city water, very pure and soft. One very instructive case he notes: Cholera broke out in a suburb, built high and dry on a limestone ridge, the air pure and bracing, drainage excellent, but the water mostly derived from wells sunk in the rock. Few persons here escaped cholera, except a family here and there who had no well, but depended upon the city supply.

After the epidemic at Paisley had subsided, it was found that there had been 848 cases of cholera, and it was estimated that the district supplied by wells contained only about one-tenth of all the inhabitants of the town, the other nine-tenths of the people using city water. It was found that this one tenth that used well water had no less than 502 cholera cases among them, while the other nine-tenths, who used pure water, had only 346 cases—that is, taking the average rate of illness among the nine-tenths of the people of Paisley, the one-tenth should have had only 39 cases instead of 502, which they *did* have, apparently from using hard water alone

All large consumers of water find hardness to be a nuisance in many trades, especially to those using steam, the reason being that hard water is largely contaminated with carbonates and sulphates, the former held in solution by carbonic acid, the latter by the water itself. When the water is vaporized the $CO_2$ is driven off by the heat, and the water at once becomes turbid by the separation and deposition of the carbonates, which settle as "scale" on the boiler and flues. As soon as the water becomes somewhat concentrated by continuous vaporization, the sulphates begin to add to the deposit by slowly separating out and falling to the lowest part of the boiler. These compound deposits, known to all housewives as "fur in the tea-kettle," and to engineers as "scale," are not only a source of expense, from being non-conductors of heat, but at times

Five minutes occupied in studying this table will be well spent, as the figures are from the highest authority, and guaranteed correct; any one unfamiliar with the subject may get a better idea of what makes water good or bad by looking over the table than reading a large book.

Organic materials find their way into water from various sources, any decomposing animal or vegetable substances being a convenient point of origin, such as dead bodies of animals, or drainage from cemeteries, leakage of sewage or sewer gas, soakage into wells, or water courses from heavily manured fields, barn-yards, pigsties, or *any other* focus of decomposition.

A few examples will illustrate this fact. During the two cholera epidemics of London, it was found that two water companies, the "Lambeth" and the "Southwark," had laid their mains side by side through many streets, thus supplying water to the same neighborhoods all over London.

Some people took of one company, some of the other, to the amount of 500,000 individuals, who were as evenly as possible divided among the two companies, being in the same condition elsewise as regards cleanliness, social status, and respectability. It was discovered, however, that those supplied by the "Lambeth" company died at the rate of 37 per 10,000, while the "Southwark" people died at rate of 130 per 10,000. It was at once suspected that the different mortality was probably influenced by some difference in the nature of the waters, and on examination it was discovered that while the "Lambeth" company went *high up* the Thames for its supply, far above city sewage or tidal contamination, the "Southwark" company pumped its water at Chelsea, a point near large sewers and seriously affected by tidal changes.

The river at Calcutta is intolerably foul, being contaminated not only by many thousand dead animals cast yearly into its stream, but also with 15,000 human corpses every year. Besides all this, the contiguous population add their quota in the shape of some *forty tons daily* of various excreta!

Calcutta is now (since five or six years) tolerably well supplied by filtered water, taken out some fifteen miles up the river by pipes and reservoirs, but, even when the city is healthy, a very severe type of sporadic cholera and dysentery is seen to prevail on board ships lying in the Hooghly, due simply to the fact that the water used is drawn up the ship's side in a bucket, and, of course, foul with organic detritus.

The facts are almost identically the same at the port of Shanghai.

In the year 1859 severe enteric fever prevailed at Bristol, England, and was easily traced to contamination of the wells by sewage and soil soakage.

This is the curse of many a lovely country town where the farmers have such a fatal fondness for grouping barn-yards, pigsties, and all sorts of unmentionable nuisances in as close proximity to the *house and well as possible!* The result is, that in this country typhoid fever is *far more* a *rural* than an *urban* disease, especially in New England. This is the reason why I object to admitting that good water is "much easier had in the country than the city," for, as things are, I would much rather drink an *unknown city* water than an unknown specimen from the *country*.

These enteric fevers betray some curious facts. For example, in October, 1847, the inmates of thirteen houses, scattered in various parts of a short street in Clifton, England, suddenly went down with typhoid, and no cause was suspected until it was *accidentally found* that these thirteen houses were supplied with water from one well—the other twenty-one houses, *all well*, took water elsewhere!

The suspected well was analyzed, and found foul with sewage; the water supply was changed, and most of the sick recovered.—*Lancet*, 1859, p. 432.

Milk, *watered* from a foul well, has *repeatedly* been known to produce epidemics of enteric fever.

In Holland, during the first ten years of the century, the English expeditions suffered great loss from the so-called "Walcheren fever." The country was a vast stinking mud-bank at low-tide, and the forces on shore died by hundreds, while the men of war, lying in the rivers and exposed to all the foul *air*, carried their crews in high health! Why? The ships had water-casks filled in England; the land troops had to drink the marsh water, and died rapidly.—Davis on "Walcheren Fever," 1810, p. 15.

There is no reason why, in a *civilized* country, safe drinking water cannot be found for human beings; the fact that so many risks are run is only another example of the old adage, "*Populus vult decipere*."

The public never wakes up to any great sanitary or moral purpose until either life or property is overwhelmed by some cataclysm. When people are *compelled* to understand the necessity of hygiene by epidemics of the enteric fevers, diphtheria, croup, scarlatina, small-pox, etc., there will be found no difficulty in providing a remedy.

Until the "good time comes," let us try to formulate our knowledge as follows:

1. No water unfit for *washing in* is fit to *drink*.

2. All *soft* water possessing a visible color, taste, or odor, is *probably* unsafe, but can be made potable by bringing it up to 100° C. (212° F.), and keeping it there for five minutes.

3. Rain-water is the easiest accessible source of soft water; when caught in a proper cistern, from a clean roof, especially during the last half of a long rain, when both air and roof have been washed clean, it makes a very clear and sparkling water, and is always better after filtering through charcoal, being then *healthful*.

4. Hard waters are apt to act as a cathartic on those used to pure water, because they are generally dilute saline sol., such as we use for that purpose, medicinally.

5. Organic impurity is often the source of very fatal epidemics, and is by many believed to be one of the great sources of contagion in typhoid fever and cholera.

Remember that three-tenth grains of organic matter per gallon (one two-thousandth of one per cent.) has been known to do harm.

A tolerably accurate test, and useful if organic matter is suspected, is as follows:

Sol. A.—Take 200 com. water, add two or three drops hydrogen sulphate.

Sol. B.—Prepare a solution of permanganate of potassium of the strength of thirty-two centigrammes per liter of distilled water. Thoroughly mix *three* drops of Sol. B in Sol. A, and note time. If Sol. A is *bleached* in *less* than *ten minutes*, organic matter is probably present in sufficient quantity to do harm.—*Pro. Med. Soc. Kings Co.*

## COLD CREAM.

A RECOGNIZED formula for this popular and useful preparation is desirable both for its own sake and for the sake of elegant pharmacy. There must, we think, be something inherently good in it as a remedial agent in that it has survived so many centuries, and still retains very much of its popularity in face of so many modern competitive introductions, such as glycerine, or the still more recent hydrocarbon preparations. On the other hand, we feel that it may be retorted that there must be something inherently bad in it, in that it has been so much neglected by pharmacists and revision committees, so that no satisfactory understanding has as yet been arrived at as to what properly constitutes a cold cream. In proof of this we may state that we have for many years back collected all the formulæ that have been given for cold creams—not a few now—and no two of these, we are bound to confess, are exactly alike, while in many cases the widest divergence exists. The formulæ thus collected may roughly be divided into three classes: First, those which contain *no* rose-water, being simply ointments composed of almond oil, wax, and spermaceti, with otto of rose for perfume, or almond oil with glycerine, etc., or composed wholly of some such substitute as the hydrocarbon compound adepsine; second, those composed of almond oil, wax, spermaceti, and rose-water, together with some saponifying agent, such as solution of potass or soda, soap, borax, etc; lastly, those composed of the foregoing ingredients in variable proportion, but without the alkaline substance. The first class may be dismissed in a word—they are *not* cold creams. The second may be considered, in the great majority of instances, as inadmissible from the irritating effect which they more or less produce on excoriated and tender skins. The last, therefore are the only formulæ that ought to be considered in determining what constitutes a proper cold cream. An analysis also of this last class greatly assists in arriving at a conclusion as to the relative proportions of the different ingredients. Some of the formulæ, for example, are constructed more on the principle of being a salve for a tender conscience than a salve for a tender skin. The rose-water is added *not to make a cream*, but for the mere sake of asserting that it is present in the preparation. In other words, it is added in quantity so minute that a dexterous manipulator might easily switch the whole of it over the side of the vessel in process of stirring, so that on standing there could by no possibility be any separation. In the majority of cases, however, a uniform ratio of two parts and one part respectively is observed between the almond oil and rose water, and this again, it is needless to point out, determines to a great extent the weight of the solidifying ingredients necessary to be added. In the case of the United States Pharmacopœia formula the proportions are as near as possible 2 parts almond oil, 1 part rose-water, ½ part spermaceti, and ½ part white wax. In the recommendations of the Revision Committee the relative proportions of the two first ingredients have still been retained, but the proportion of spermaceti has been slightly increased, and paraffin has been substituted for white wax, while a blank quantity of glycerine is suggested to replace part of the rose-water, and the further addition of soap-powder or borax is also suggested. Nothing could better illustrate the unsatisfactory state of the subject than these recommendations. Evidently dissatisfaction is felt with the existing formula or no change would have been proposed, and equally apparent is it that no definite conclusions have been arrived at or there would not have been so many alternative suggestions given. In these circumstances it might be considered hazardous to give either formula or opinion on the subject were it not for the fact that many seem glad of any suggestions, however insignificant. We submit the following in the conviction that as many fail in making a good cream from want of knowing *how* to make it as from want of a proper formula from which to make it

In the first place, it seems to be sometimes overlooked that cold cream may be treated either as a simple mechanical mixture or as a proper emulsion, and that, according as it is treated either as the one or the other, so will there need to be a modification, not only of the solidifying ingredients entering into its composition, but also of the manipulations in preparing it. To mix one part of rose-

water in two parts of almond oil in presence of wax and spermaceti is no very difficult task, and might be accomplished even by a novice, but to mix them so that they will not only be inseparable, but will also mix with other substances without separation, requires something more than the bare knowledge gained from such directions as "misce," "fiat secundum artem," or "stir constantly while cooling," which generally accompany such formulæ. Another point we fear frequently overlooked is that in preparing cold cream the attention should not be divided between it and other duties, doing this and that, and stirring the cream between hands. Manipulation such as this is sure to end in failure, and probably accounts for much of the dissatisfaction felt with the formula from which it happens to be prepared. A good preparation can be made from many of the published formulæ, keeping these two points in view; but, if further directions are necessary, attention must be given more minutely to the effect that manipulation has on the preparation itself, and also on the relative proportions of the different ingredients entering into it. In the case of all ordinary ointments, cold cream included, if they are stirred till cold, and then allowed to stand for some time undisturbed, they will set more or less—that is, they get firm throughout the whole mass. In this condition cold cream, if again stirred or broken up, will separate more or less, according as the ingredients have been in a coarser or finer state of mechanical subdivision. If it is at all allowed to set, this separation will take place sooner or later on being disturbed. If, on the other hand, the ointments, instead of being allowed to set, are thoroughly whipped up from time to time at short intervals, they will, instead of setting, get softer, and if the whipping is continued for a given time they will continue permanently and uniformly soft. Thirty years ago—probably more now—when but a novice in matters pharmaceutical, we received lessons in thus creaming, as it was called, the ointments and pomades which we have never forgotten, and which has often proved useful to us since. We were kept for hours at a time whipping the ointments until they had quite lost their granular fracture on digging out with a spatula, and had assumed a smooth, silky appearance. Now, if cold cream be treated skillfully in this way, it passes from the state of what is best called a mechanical mixture into the condition of a proper emulsion—that is to say, the mixture is permanent for any length of time, it may be stirred without separating, and is quite miscible with other substances where heating is not required. Further, when treated in this way the cold cream softens considerably, so that the proportions of wax and spermaceti necessary to make another cream which is simply stirred till cold, and then set aside, is quite unsuited for one which is prepared as now described. In this lies probably one explanation of the diversity of the proportions of wax and spermaceti given in different formulæ, as well as one explanation also of occasional failure to obtain a good cream, even where the same formula has been employed. No two operators will exactly judge alike as to when the preparation may be termed cold, and, consequently, when to stop stirring, and probably the same operator does not on every occasion cease when the cream is in a like condition. Hence, while each judges as to the proper proportion of wax and spermaceti for his mode of operation, it does not follow that his formula will suit the mode of operation pursued by others, nor does it even follow that success will in every case attend his own efforts, seeing the circumstances as thus explained are not always alike.

Taking the U. S. Pharmacopœia proportions as already given, and treating them as just explained, a cream will be obtained which, when properly emulsified, will pour from the jar. This is evidently too thin for ordinary use. We have not tried the Revision Committee's formula, as we have not only a strong dislike to the paraffin suggestion, and a stronger dislike still to the saponifying ingredient, but we have also a dislike to part with an old friend, from which we have always obtained good results. The formula referred to is as follows:

| | |
|---|---|
| Almond oil | 8 parts. |
| Rose-water | 4 " |
| Wax | 1½ " |
| Spermaceti | 1½ " |

Proceed as above described. If failure follows the use of this formula we cannot but conclude that the error is not in the formula but in the operator. In recommending it, however, we would suggest that the preparation of an emulsion be properly understood and kept in mind. Every one with the least experience knows that it cannot be made haphazard. The unmixable ingredient must be added gradually, with constant and uniform motion of the emulsifier, and with general application of the element termed brains. So with cold cream; the rose-water must be slowly added to the melted ingredients when they are neither too hot nor too cold; the stirring must be constant, always in one direction, and experience alone must decide the proper moment for the stirring to cease, and the occasional whipping to be substituted.—*Chemist and Druggist.*

## PRESSURE APPARATUS FOR RAISING BEER.

BEER was formerly consumed principally in particular places, such as smoking-rooms, brew-houses, etc.; and, when kept on sale by cafés, large or small, was served only in bottles or small jugs. But, during the last twenty years, things have changed, and this beverage is now retailed everywhere in mugs or goblets, except perhaps by second-class wine merchants. Now beer can be drawn directly from the cask only in establishments whose retail trade is large; for, in order that this beverage shall preserve all its qualities, a cask once tapped must be consumed during the same day, inasmuch as a gradual withdrawal of the liquid diminishes the pressure and has a tendency to make the beer flat.

In order to obviate such an inconvenience and to have a means of preserving a cask of beer on tap unimpaired for a longer length of time, several methods have been proposed. One of the best of these is a compressing system, which is now largely used in Paris, and which we illustrate herewith. This system comprises the use of an apparatus for forcing air into the cask containing the beer. By the aid of such pressure the liquid is raised from the cellar to the retail faucet. The system permits, then (1), of keeping the casks in the cellar, where the temperature is low and constant, and (2), of keeping the beer at a pressure which allows it all times to be saturated with carbonic acid. This latter feature is a capital one, inasmuch as beer deprived of carbonic acid is a beverage without value.

Pressure by means of carbonic acid, which was in much favor five or six years ago, has at the present day been almost wholly discarded. The gas was produced by means of carbonate of soda and hydrochloric acid; but whatever were the precautions taken or whatever were the systems adopted (for there were several), the beer, to a consumer of delicate taste, always retained a peculiar flavor derived from the acid that was carried along with the gas.

The system of pressure by air, which is illustrated in Figs. 1 to 4, includes the following apparatus:

A. Air inlet;
B. Air pump;
C. Air reservoir;
D. Distributer;
E. Air pipes;
F. Compressing device, properly so-called;
G. Connecting pipes;
H. Worms;
I. Retail faucets.

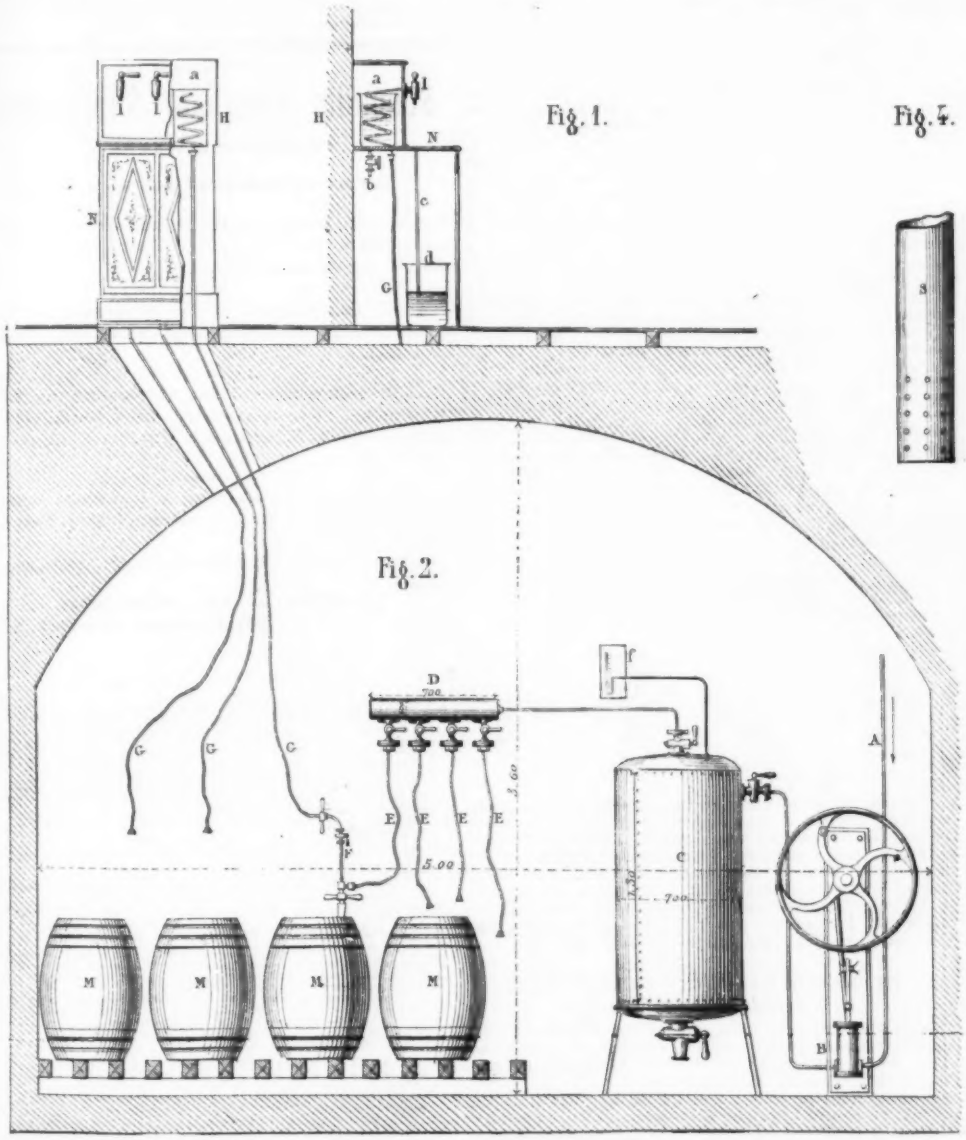



Fig. 1.

Fig. 2.




Fig. 4.

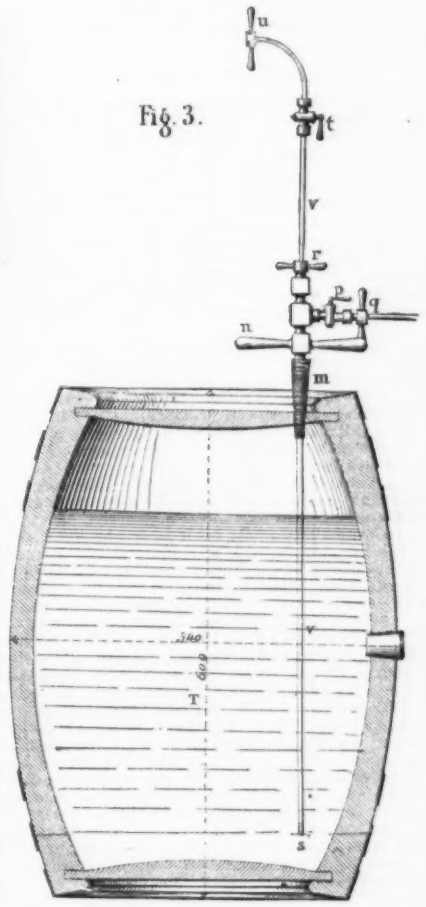



Fig. 3.

FIG. 1.—SECTION OF FAUCET STAND. FIG. 2.—ELEVATION. FIG. 3.—THE COMPRESSING DEVICE. FIG. 4.—EXTREMITY OF THE FORCE PIPE.

The entrance of air is effected through a tube whose aperture debouches into the atmosphere. The air is sucked in by the pump B, which ordinarily is placed on a strong, horizontal oak base. A hand-wheel, a connecting-rod, and a guide for the piston-rod constitute the parts for maneuvering the air-pump, the internal diameter of which is usually 6 to 8 centimeters. The valve of the pump is put in communication with the air-reservoir by means of a tube of 15 to 20 millimeters, provided with a cock.

The air-reservoir, C, is of iron plate and is cylindrical, its height being 1·2 to 1·3 meters, and its diameter 0·6 to 0·8 of a meter. It is placed in a vertical position at a certain height above the floor, and into its base there is inserted a pretty large blow off cock. In one side there is a man-hole for cleaning purposes, and at the upper part there is a small tube which leads to a mercurial pressure-gauge of very simple construction.

The distributer, D, is a cylinder of iron (or sometimes, of what is better, copper), of a length which varies according to the size and trade of the establishment, and of a diameter of about 80 to 100 millimeters. This distributer communicates with the upper part of the air-reservoir by means of a tube, and carries a series of cocks to which are affixed tubes

of rubber, gutta percha, or even of tin. These air-tubes usually possess an internal diameter of 10 to 15 millimeters, and terminate in a coupling which permits of their being connected with the compressor.

Under this latter name is designated the apparatus which is inserted into the head of the cask put on tap. Its details are as follows: V is a tube, whose extremity is represented at S (Fig. 4), of actual size. This extremity slides by hard friction through a piece of brass which forms the conical threaded plug which is screwed through the bung-hole in the head of the cask. The tube slides in a stuffing-box which is tightened up by a follower. Under this stuffing-box there is fixed latterly a cock, *p*, which carries a coupling, *q*, from which branches the air-tube. Following the cock comes the threaded cone, *m*, which is provided with two handles, *n*, that permit of screwing it tightly into the head of the cask, T.

The compressed air enters through the cock, *p*, circulates between the movable tube and the piece of brass, and finally enters the cask through the annular space left between the cone, *m*, and the movable tube, V. The compressed air is thus imprisoned between the stuffing-box, *r*, and the surface of the beer. The latter then rises into the tube, V, whose lower extremity is pierced at the sides with small holes, and whose upper carries a coupling, by means of which it is affixed to the draught pipes, G. These latter, which are of tin, and 10 to 12 millimeters in diameter, run up to the bar-room above and enter a stand arranged somewhat like a wash-stand. This piece of furniture is provided with faucets, I, I, I, the number of which will depend upon the trade of the establishment. But before the beer reaches the faucets it circulates through a worm in which the tube, G, terminates. This worm, which is likewise of tin, is inclosed in a zinc box, into which ice is put during the warm season. Experience has shown that the temperature preferred by beer-drinkers is 8°. It is rarely the case that the temperature of the cellar is such Under the marble tablet of the stand there is placed a vessel to catch the drippings from the faucets or the overflow of the glasses that are being filled.

## SOME EXPERIMENTS WITH DIFFERENT QUALITIES OF ILLUMINATING GAS USED IN AN "OTTO" GAS ENGINE.*

By CHARLES HUNT, M. Inst. C.E.

THE gas engine may be justly described as one of the most successful achievements of modern times. It has won its way to favor by dint of sheer merit, and its proved economy in relation to expenditure of power has stimulated prediction as to its future almost to the verge of unreasonableness. Having within a very brief space of time established itself as a source of consumption by no means inappreciable, it is already regarded as a powerful rival and possible supplanter of steam power. Illuminating gas, however, is not, without a struggle, to be allowed the credit of working so great a change; for strenuous efforts are being directed to the introduction of a separate, and, as it is believed, competing method of furnishing the necessary supply of combustible gas.

It is a striking testimony to the merit of the engine that a gas producer, in virtual substitution of the familiar steam boiler, may result in so great a saving to the user as was shown to be possible by Professor Ayrton in his lecture, delivered last year at the Electrical Exhibition in Paris; and proves, beyond all reasonable doubt, the superiority of direct conversion of coal into motive power, even in the face of difficulties which further experience and the progress of invention may be expected at least to mitigate. Nor can it be needful to seek to controvert the proposition directed against gas manufacturers, that consumers may derive benefit by becoming their own producers; for it is one by which they have always been confronted, and the practical effect of which, as evidenced by the almost total disappearance of private works within their limits of supply, has become weak in proportion to the growth and strength of the undertakings. There is nothing inherently superior in any process of complete gasification, as distinguished from destructive distillation, but rather the reverse; and the only saving to the consumer who should adopt it would be in the cost of distribution and manufacturer's profit. On the other hand, it is looked upon as a prime advantage of the gas engine that it places the user of it in a position of complete independence, not only as regards boiler appliances, but also of all kinds of fuel other than that which is supplied to him without inconvenience to himself or risk of failure, at all times and seasons, and without the necessity for any intermediary process of conversion. It is this, quite as much as from any considerations of economy, that has brought the gas engine so rapidly into use, and may be safely relied upon for securing to gas makers the chief participation in the demand for gaseous fuel which it has created.

The calorific value of different qualities of illuminating gas is a subject that has been much under discussion; and it has come to be generally recognized, as the result of experiments, that the higher the illuminating power the greater the heating value, although not by any means in the same proportion. Mr. J. L. Bruce has recently quoted Dr. Wallace as his authority for the following table, from which it appears that increases in illuminating power of, in round figures, 77 and 120 per cent. correspond with increases in heating value of only 30 and 50 per cent. respectively:

| Candle Power of Gases. | Comparative Specific Gravity. | Value for Heating. | Value for Lighting. |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 14·75 | 1·000 | 1·000 | 1·000 |
| 26·24 | 1·187 | 1·295 | 1·769 |
| 33·07 | 1·298 | 1·496 | 2·230 |

Upon the heat of combustion depends the action of the gas engine, and its effect as developed therein should be a measure of heating value of almost unfailing accuracy. Apart from this, however, it is of practical importance to know, with as much precision as circumstances will admit of, the relative values of different qualities of illuminating gas when employed for this specific purpose; and it was with this object, and for determining other matters incidental to it, that the experiments which form the subject of this paper were undertaken.

The gas used in each case was the absolute product of coal or cannel distilled and purified in the ordinary way, with the exceptions that will be further referred to. No admixture of air was permitted, the poorer gas being made with South Staffordshire small coal or slack, the 15-candle with a somewhat better coal, and so on; the higher qualities being obtained from a mixture of coal and cannel. The burners used for testing were a No. 1 "London" argand, with suitable chimney, for all gases up to and including from 17 to 18 candles, and beyond that a steatite batswing.

Before commencing the trials, the engine was thoroughly cleaned, and all bearings adjusted and lubricated, so as to avoid any undue friction. The diagrams were all taken with a Richards indicator, and three times repeated, six such diagrams being taken for each quality of gas; so that the final results, which were calculated in the ordinary way, as shown on the table of summaries (No. 7), are each of them the average of eighteen indications. It was noticed with regard to all the gases, that the regular explosion was missed once in about 35 or 40 revolutions, the following explosion being of greater than average force, succeeded by one of diminished intensity. This abnormal explosion was not in any case taken account of.

The gas being applied at a uniform pressure, it was noticed during the trials that the speed of the engine entirely depended upon the extent to which the gas valve was open or closed. For instance, with the valve adjusted for 17-candle gas, the engine could not be made to start with 29-candle gas. This, perhaps, follows as a matter of course, from the fact that the best results are obtained when using the richer gas, with a smaller quantity than is required of the poorer gas; and points to the desirability of determining, in each individual case, the pressure at which the gas requires to be delivered in order to obtain the maximum effect. Otherwise, not only waste of gas, but also loss of power, is likely to ensue.

Before taking any diagrams the engine was weighted with its maximum load, by which means an explosion was secured, practically, every second revolution, or fourth stroke. The actual horse power was ascertained by applying a strap brake to one fly-wheel, this being fixed to a suitable frame, and having an adjustable spring balance at either end. From the friction so obtained the horse power was determined, and deducting this from the indicated horse power, in which the power expended in compressing the charge is not included, the loss due to the friction of the engine was obtained. This is shown to average 25·11 per cent., which on first thought appears high; but it is really less, if anything, than that which obtains with steam engines of corresponding size.

The general tendency observed throughout the experiments was toward a deeper diagram with the richer gases, apparently indicating a slower combustion, and slightly greater force exerted throughout the stroke.

As shown by the table of summaries, the quantity of gas expended per horse power varies considerably with its quality. The following table, constructed on the model of Mr. Bruce's, shows that this variation is, in the case of the poorer gases, in almost direct proportion to the difference in quality; but that there is a marked want of correspondence with the higher qualities. The greatest difference, however, is only as 100 : 140, which is much less than that shown by Dr. Wallace to subsist with regard to the calorific values of similar gases; although why, it may not be very easy to determine.

| Illuminating Power of Gas. Candles. | Consumption per Indicated Horse Power per Hour. Cubic Feet. | Value for Motive Power. | Value for Lighting. |
|---|---|---|---|
| 11·96 | 30·31 | 1·000 | 1·000 |
| 15·00 | 24·41 | 1·241 | 1·254 |
| 17·20 | 22·70 | 1·335 | 1·428 |
| 22·85 | 17·73 | 1·709 | 1·910 |
| 26·00 | 16·26 | 1·864 | 2·173 |
| 29·14 | 15·00 | 2·020 | 2·436 |

The gas used in some of the experiments was made according to the method suggested by Dr. Siemens; the poorer gas representing the first and the last portions of ordinary charges, and the richer the middle portion. There is practically little or no difference in value between the gas so obtained and that which was made in the ordinary way. Whether produced by one method or the other, the lower the illuminating power the greater is the quantity required to perform the same amount of work.

* A paper lately read before the Gas Institute, London.

## DETERMINATION OF SALICYLIC ACID.

By MM. PELLET and DE GROBERT.

A VOLUMINOUS memoir, in which the authors describe the determination of salicylic acid in butter, milk, and urine. The process is volumetric, and the authors make use of a colorimetric of ferric chloride at 1·005 to 1·008 sp. gr., containing 0·5 grm. acid in 100 c. c. They take 25 grms. butter, place it in a cylinder graduated at 200 c. c., add 5 or 6 drops of sulphuric acid at 30° B., and a certain volume of benzol, *e. g.*, 75 c. c., and shake strongly. All the fatty substance is dissolved, and a whitish matter remains in suspension. The total volume is noted, and is made up exactly 100, 110, or 120 c. c. The solution is filtered; 5 or 10 c. c. of it are taken, and placed in a test-tube of the same diameter as the tubes of the colorimeter; 5 or 10 c. c. of water are added, and 2 or 3 drops of the ferric chloride above mentioned. The tube is shaken repeatedly, but gently, to prevent an emulsion, and when the tint of the lower liquid no longer deepens, it is compared with a standard tube. For greater exactitude the comparison is made not with a tube containing merely water, but with a tube in which is a solution of benzol having dissolved 25 grms. of butter free from salicylic acid per 100 c. c. We place 10 c. c. of this normal solution of butter free from salicylic acid in a test-tube; then 0·2 c. c. or 0·1 c. c. of a solution of salicylic acid at 1 grm. per liter, and 9·8 c. c. or 9·9 c. c. of distilled water; then, lastly, 2 drops of the ferric chloride, and agitate. The proportion of salicylic acid is judged by the comparative color.

## ABSORPTION OF GASES BY PLATINUM.

By M. BERTHELOT.

THE study of electrolytic polarization has led the author to investigate the heat disengaged in the absorption of gases by platinum, especially as regards hydrogen and oxygen. He has operated with platinum in various forms, inclosed in small glass globes holding about 75 c.c. fitted with taps, and containing from 50 to 120 grms. of metal. They were placed in a calorimeter, the globes were exhausted, weighed, and the gas was then admitted so as to saturate the platinum at a pressure as near as possible to that of the atmosphere. On weighing again the increase of weight gives the gas absorbed. When this is done the gas is withdrawn by means of the mercurial pump, at first in the cold, and then at 200°, measuring each time the gas, and noting the losses of weight consecutive on its extraction. This is then completed by collecting the gases set at liberty, and heating the metal in a tube of hard glass until the glass begins to melt, —an indispensable counter-proof, without which there is sometimes danger of attributing to a hydride the absorption of oxygen, due in reality to the reduction of a platinum oxide, or to regard as due to some particular state of the platinum an absorption of oxygen, which is in reality due to the oxidation of a hydride. Such hydrides and sub-oxides seem to have been often confounded with platinum itself in the study of the substances called platinum black. The author finds evidence of two distinct platinum hydrides, the one dissociable and capable of being oxidized in the cold by oxygen, and the other more stable, but capable of being destroyed by the action of heat. All the specimens of platinum-black which the author has been able to procure contained considerable proportions of oxygen, and were sub-oxides. They absorb large proportions of hydrogen, one part of which reduces the oxide, while another part forms a hydride. Platinum, in whatever state, if placed in a vacuum and then exposed to oxygen, becomes heated distinctly. The ignition of a mixture of hydrogen and oxygen by platinum is occasioned by the formation of the less stable hydride and its oxidation in the cold by oxygen.

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TABLE OF CONTENTS.

PAGE

I. ENGINEERING AND MECHANICS.—The Panama Canal. By MANUEL EISSLER, M.E. (continued from No. 345) III. The Isthmus of Panama.—Topography and geography.—Early surveys for canal projects.—Rivers and rainfall.—Passes.—Winds.—Tides.—Sea Currents.—Climate.—Vegetation.—Health, etc. 5503
Improved Silk Reel.—1 figure.—New iron frame silk reel constructed for the Women's Silk Culture Association 5505
Automatic Boiler Feeder and Condenser Feed Water Heater. Fromentin's system.—16 figures.—Applications of automatic boiler feeder to stationary and locomotive boilers 5506
Battery and Copper Plate Amalgamation. By PROF. R. H. RICHARDS 5507

II. TECHNOLOGY AND CHEMISTRY.—Reduction of Photographic Wastes. By W. L. SHOEMAKER 5511
Pressure Apparatus for Raising Beer.—4 figures 5505
Some Experiments with Different Qualities of Illuminating Gas used in an Otto Gas Engine. By CHARLES HUNT 5508
Determination of Salicylic Acid. By MM. PELLET & DE GROBERT 5509
Absorption of Gases by Platinum 5509

III. NATURAL HISTORY, ETC.—Science of the Horse's Motion.—1 large illustration.—A hunting episode, with many figures, showing the real and the ideal positions of a galloping horse.—Art contrasted with instantaneous photography 5511
On the Condition and Characteristics of Some of the Native Tribes of the Hudson's Bay Company's Territories. By JOHN RAE.—A very interesting account of the Indians of the north, their modes of life and the animals they hunt for food and furs 5512
Man and Nature in Northern Alaska 5515

IV. HYGIENE AND MEDICINE.—On the Care of the Insane.—Report of New York State Committee of Investigation.—Insanity increasing.—Pauper insane.—Small hope of cure.—Partially and mildly insane.—Care of the insane in other countries.—A Humane method demanded.—Value of State supervision 5511
General Hints to the Dispenser 5509
On Smell. By WILLIAM RAMSAY.—Organs and limitations of the sense of smell.—Only gases are odorous.—Chemical basis of odor.—Relation of molecular weight to smell.—Vibration theory of smell 5513
Our Drinking Water. By Dr. N. B. SIZER.—Pure water hygienically necessary.—Good city water supplies compared.—Effects of impure water.—Relation of certain epidemics to water supply.—What water is fit to drink.—Tests 5516
Cold Cream 5516

V. ELECTRICITY, LIGHT, ETC.—The Baudot Multiplex Printing Telegraph.—6 figures.—Theoretical diagram of sextuplex telegraphs.—Manipulator.—Receiver.—Receiving relay.—Distributer.—Secondary Batteries 5518
On a New Form of the Aperiodic Galvanometer. By MARCEL DEPREZ.—2 figures 5520
Microscopes and Microscopy. By Dr. ROYSTON PIGOTT.—Nature of light.—Water sight.—Uses of the microscope.—Nature study.—Wonders of insect life.—Power of the eye 5520

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